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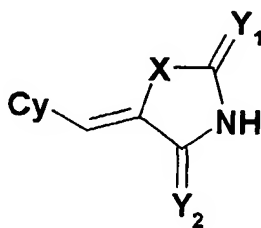
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(54) Title: USE OF COMPOUNDS FOR INCREASING SPERMATOZOA MOTILITY



(I)

(57) Abstract: The invention relates to a process for the improvement of sper-  
matozoa fertilization activity, in particular for the increase of spermatozoa motil-  
ity, by using a compound of formula (I). The invention further relates to uses  
and methods of compounds of formula (I) in infertility and assisted reproduc-  
tion techniques (ART) as well as to a medium for storage and/or transportation  
of spermatozoa comprising said P13K inhibitors.

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## Use of compounds for increasing spermatozoa motility

### Field of the invention

The invention relates to a process for the improvement of spermatozoa fertilization activity, in particular for the increase of spermatozoa motility by using a compound of formula (I). The invention further relates to the use of a compound of formula (I) in the treatment of infertility and assisted reproduction techniques as well as methods of use thereof, and to a medium for storage and/or transportation of spermatozoa comprising the use of a compound of formula (I).

### Background of the invention

The infertility of a couple is defined as the inability of the woman to conceive after at least a year of regular unprotected sexual relations. Infertility may be caused by a multitude of factors, in which male factors play a fundamental role in around 40-50% of cases. Reduced male fertility is generally linked to alterations in seminal parameters such as morphology, motility and sperm count.

Various assisted reproduction techniques (ARTs) are proposed as treatment for infertility of the couple, in many cases making it possible to overcome the problem of both male and female factors. These methods, the choice of which depends on the type of diagnosis made, may involve the collection of male and female gametes (spermatozoa and oocytes). The further treatment varies according to the cause of the infertility. The gametes may be transferred directly into the Fallopian tube (GIFT= Gamete Intra Fallopian Transfer) or are brought into contact with each other in a test tube. If the latter leads to fertilization of the oocyte, the resulting zygote or embryo is transferred into the uterus (IVFET = In Vitro Fertilization and Embryo Transfer).

When infertility is due to male factor(s), parameters of the seminal liquid and in particular the count and motility of spermatozoa determine the choice of the particular assisted fertilization method used. In the most serious cases of male-factor infertility the spermatozoa count and/or their motility is very low. The fertilization activity of semen is usually assessed in a spermogram. According to WHO standards, which can be taken from the "WHO manual" (WHO laboratory manual for the examination of human semen and sperm-cervical mucus interactions, 4<sup>th</sup> edition, Cambridge University Press 1999), semen are classified into the following groups:

- Normozoospermia: When all the spermatozoal parameters are normal together with normal seminal plasma, WBCs (White blood cells) and no agglutination;
- Oligozoospermia: When sperm concentration is < 20 million/ml;
- Teratozoospermia: Fewer than 50% spermatozoa with forward progression (categories (a) and (b)) or fewer than 25% spermatozoa with category (a) movement;
- Asthenozoospermia: Fewer than 50% spermatozoa with normal morphology;
- Oligoasthenoteratozoospermia: Signifies disturbance of all the three variables (combination of only two prefixes may also be used);
- Azoospermia: No spermatozoa in the ejaculate.

Normal values of semen parameters have been issued by WHO that are generally used as reference. The fraction of motile sperm in semen is measured either by manual counting or using a computer assisted semen analysis (CASA) system. Motility is assessed at the time of semen liquefaction and after 1 and 3 hours to detect asthenozoospermia. Manual counting classifies sperm cells into 4 categories (immotile, locally motile, non linear and linear motile) using qualitative subjective criteria of selection. Many infertility centers now use CASA systems for objective measurements of sperm motion and positive correlations have been found between motion parameters such as the amplitude of lateral head displacement, curvilinear velocity, linearity and straight-line velocity and fertilization rates

*in vitro* but the threshold levels for these motion characteristics have not yet been established to meet a general consensus.

In case of severe male factor infertility, micro-assisted fertilization techniques can be used.

Among these techniques, intracytoplasmatic sperm injection (ICSI) is the most common and has the highest percentage of success. However, the safety of the ICSI procedure for the health of the resulting conceptus or embryo is still matter of debate (*Nature Medicine* 5, 377-378 (1999) by Edwards RG). In addition, ICSI is far more expensive and more time consuming as compared to IVF.

Thus, the possibility to recover a higher number of spermatozoa showing a higher motility could allow several oligoasthenospermic men to enter IVF rather than ICSI programs.

Various methods have attempted at increasing the motility of the spermatozoa, like treatment of spermatozoa with pentoxifyllene, platelet activating factor or progesterone, for instance. However, the results obtained are variable and the responsiveness of the spermatozoa is not predictable.

Therefore, the finding of new methods and agents to improve sperm cell motility, leading to an improvement of the fertilization activity or fertilization rate, is highly desirable and urgently needed. These are objects of the invention to provide new methods and process to improve said sperm cell motility by using specific phosphatidylinositol-3-kinases inhibitors.

These phosphatidylinositol-3-kinases (PI3Ks) belong to a family of enzymes involved in signal transduction of tyrosine kinase receptors. Phosphatidylinositol-3-kinases, also called phosphoinositide-3-kinases (PI3Ks) generate lipids which are implicated in receptor-stimulated signalling and in the regulation of membrane traffic. Several distinct classes of PI3Ks have been identified that have been conserved throughout eukaryotic evolution.

Potential signalling pathways downstream of PI3Ks have been elucidated and PI3K function is being characterized in several model organisms, as reviewed e.g. by Vanhaesebroeck et al. (*Trends Biochem. Sci.* 22 p.267-72 (1997)). PI3Ks are heterodimeric



enzymes present in various isoforms and composed of a catalytic subunit of 110 kDa, which is associated with a regulating subunit of 85 kDa.

In somatic cells phosphoinositide-3-kinases (PI3-kinases) are activated upon interaction with both receptor tyrosine kinases (RTK) and G-proteins resulting in the production of moieties involved in the inositol phospholipid signalling pathway. The enzyme is also present and active in human spermatozoa.

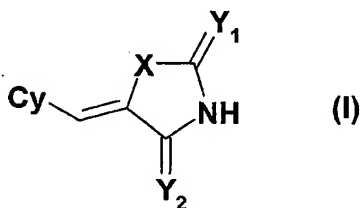
Several selective inhibitors of PI3Ks have been described. Wortmannin is one of the most well-known specific inhibitors. Wortmannin is a fungal metabolite derived from *T. wortmanin* (Kyowa Hakko Kohyo Co. Ltd.) or from *P. fusiculosum* (Sigma). Wortmannin and analogs thereof have already been described in patent literature (e.g. EP0635268 A1, EP0648492 A2 or EP0658343 A1). These compounds are known to be involved in the treatment of neoplasms, atherosclerosis, and bone disorders. Other phosphatidylinositol-3-kinase inhibitors are 2-(4-morpholinyl)-8-phenyl-4H-1-benzopyran-4-one (LY294002), and bioflavonoid quercetin for example described in Vlahos et al. in (*J. Biol. Chem.* **269**, p.5241-48 (1994)) and (*J. Immunol.* **154**, p.2413-22 (1995)).

The use of PI3K inhibitors in a process for the improvement of spermatozoa fertilization activity as well as for the preparation of a pharmaceutical composition in the treatment of infertility, particularly male infertility, has been disclosed by Applied Research Systems ARS Holding N.V. (WO 01/07021). In said patent, PI3K inhibitors are selected from the group consisting of 2-(4-morpholinyl)-8-phenyl-4H-1-benzopyran-4-one (LY294002), wortmannin, quercetin and derivatives and analogues thereof.

It has now been found in accordance with the invention that phosphatidylinositol-3-kinase inhibitors of formula (I) can improve the parameters determining sperm cell fertilization activity, in particular the sperm cell motility.

### Summary of the invention

The invention therefore relates to a method of enhancing spermatozoa fertilization activity, in particular of increasing the motility of the spermatozoa, comprising the step of treating the spermatozoa by using a compound of the following formula (I)



wherein X, Y<sup>1</sup>, Y<sup>2</sup> and Cy are defined in detail in the description below.

The invention further relates to spermatozoa in which the activity of the phosphatidylinositol-3 kinase is inhibited, as well as the use of a compound according to formula (I) for improving the fertilization rate in assisted reproduction techniques (ART).

A third aspect of the invention concerns the use of a compound of formula (I) for the preparation of a pharmaceutical composition for the treatment of infertility, in particular male infertility. A fourth aspect of the present invention relates to methods of ART therapy comprising treating spermatozoa with a compound of formula (I). A fifth aspect of the invention relates to a medium for storage and/or transportation of spermatozoa containing a compound of formula (I).

### Description of the invention

The following paragraphs provide definitions of the various chemical moieties that make up the compounds according to the invention and are intended to apply uniformly throughout the specification and claims unless an otherwise expressly set out definition provides a broader definition.

“C<sub>1</sub>-C<sub>6</sub> -alkyl” refers to monovalent alkyl groups having 1 to 6 carbon atoms. This term is exemplified by groups such as methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, *tert*-butyl, n-hexyl and the like.

"Aryl" refers to an unsaturated aromatic carbocyclic group of from 6 to 14 carbon atoms having a single ring (*e.g.*, phenyl) or multiple condensed rings (*e.g.*, naphthyl). Preferred aryl include phenyl, naphthyl, phenantrenyl and the like.

5 "C<sub>1</sub>-C<sub>6</sub>-alkyl aryl" refers to C<sub>1</sub>-C<sub>6</sub>-alkyl groups having an aryl substituent, including benzyl, phenethyl and the like.

"Heteroaryl" refers to a monocyclic heteroaromatic, or a bicyclic or a tricyclic fused-ring heteroaromatic group. Particular examples of heteroaromatic groups include optionally substituted pyridyl, pyrrolyl, furyl, thienyl, imidazolyl, oxazolyl, isoxazolyl, thiazolyl, isothiazolyl, pyrazolyl, 1,2,3-triazolyl, 1,2,4-triazolyl, 1,2,3-oxadiazolyl, 1,2,4-oxadiazolyl, 1,2,5-oxadiazolyl, 1,3,4-oxadiazolyl, 1,3,4-triazinyl, 1,2,3-triazinyl, benzofuryl, [2,3-dihydro]benzofuryl, isobenzofuryl, benzothienyl, benzotriazolyl, isobenzothienyl, indolyl, isoindolyl, 3H-indolyl, benzimidazolyl, imidazo[1,2-a]pyridyl, benzothiazolyl, benzoxazolyl, quinoliziny, quinazolinyl, pthalazinyl, quinoxaliny, cinnoliny, naphthyridiny, pyrido[3,4-b]pyridyl, pyrido[3,2-b]pyridyl, pyrido[4,3-b]pyridyl, quinolyl, isoquinolyl, 10 tetrazolyl, 5,6,7,8-tetrahydroquinolyl, 5,6,7,8-tetrahydroisoquinolyl, purinyl, pteridinyl, carbazolyl, xanthenyl or benzoquinolyl.

"C<sub>1</sub>-C<sub>6</sub>-alkyl heteroaryl" refers to C<sub>1</sub>-C<sub>6</sub>-alkyl groups having a heteroaryl substituent, including 2-furylmethyl, 2-thienylmethyl, 2-(1H-indol-3-yl)ethyl and the like.

20 "C<sub>2</sub>-C<sub>6</sub>-alkenyl" refers to alkenyl groups preferably having from 2 to 6 carbon atoms and having at least 1 or 2 sites of alkenyl unsaturation. Preferable alkenyl groups include ethenyl (-CH=CH<sub>2</sub>), n-2-propenyl (allyl, -CH<sub>2</sub>CH=CH<sub>2</sub>) and the like.

"C<sub>2</sub>-C<sub>6</sub>-alkenyl aryl" refers to C<sub>2</sub>-C<sub>6</sub>-alkenyl groups having an aryl substituent, including 2-phenylvinyl and the like.

25 "C<sub>2</sub>-C<sub>6</sub>-alkenyl heteroaryl" refers to C<sub>2</sub>-C<sub>6</sub>-alkenyl groups having a heteroaryl substituent, including 2-(3-pyridinyl)vinyl and the like.

"C<sub>2</sub>-C<sub>6</sub>-alkynyl" refers to alkynyl groups preferably having from 2 to 6 carbon atoms and having at least 1-2 sites of alkynyl unsaturation, preferred alkynyl groups include ethynyl (-C≡CH), propargyl (-CH<sub>2</sub>C≡CH), and the like.

5 "C<sub>2</sub>-C<sub>6</sub>-alkynyl aryl" refers to C<sub>2</sub>-C<sub>6</sub>-alkynyl groups having an aryl substituent, including phenylethynyl and the like.

"C<sub>2</sub>-C<sub>6</sub>-alkynyl heteroaryl" refers to C<sub>2</sub>-C<sub>6</sub>-alkynyl groups having a heteroaryl substituent, including 2-thienylethynyl and the like.

10 "C<sub>3</sub>-C<sub>8</sub>-cycloalkyl" refers to a saturated carbocyclic group of from 3 to 8 carbon atoms having a single ring (*e.g.*, cyclohexyl) or multiple condensed rings (*e.g.*, norbornyl). Preferred cycloalkyl include cyclopentyl, cyclohexyl, norbornyl and the like.

"Heterocycloalkyl" refers to a C<sub>3</sub>-C<sub>8</sub>-cycloalkyl group according to the definition above, in which up to 3 carbon atoms are replaced by heteroatoms chosen from the group consisting of O, S, NR, R being defined as hydrogen or methyl. Preferred heterocycloalkyl include pyrrolidine, piperidine, piperazine, 1-methylpiperazine, morpholine, and the like.

15 "C<sub>1</sub>-C<sub>6</sub>-alkyl cycloalkyl" refers to C<sub>1</sub>-C<sub>6</sub>-alkyl groups having a cycloalkyl substituent, including cyclohexylmethyl, cyclopentylpropyl, and the like.

"C<sub>1</sub>-C<sub>6</sub>-alkyl heterocycloalkyl" refers to C<sub>1</sub>-C<sub>6</sub>-alkyl groups having a heterocycloalkyl substituent, including 2-(1-pyrrolidinyl)ethyl, 4-morpholinylmethyl, (1-methyl-4-piperidinyl)methyl and the like.

20 "Carboxy" refers to the group -C(O)OH.

"C<sub>1</sub>-C<sub>6</sub>-alkyl carboxy" refers to C<sub>1</sub>-C<sub>6</sub>-alkyl groups having an carboxy substituent, including 2-carboxyethyl and the like.

"Acyl" refers to the group -C(O)R where R includes "C<sub>1</sub>-C<sub>6</sub>-alkyl", "aryl", "heteroaryl", "C<sub>1</sub>-C<sub>6</sub>-alkyl aryl" or "C<sub>1</sub>-C<sub>6</sub>-alkyl heteroaryl".

"C<sub>1</sub>-C<sub>6</sub>-alkyl acyl" refers to C<sub>1</sub>-C<sub>6</sub>-alkyl groups having an acyl substituent, including 2-acetylethyl and the like.

"Aryl acyl" refers to aryl groups having an acyl substituent, including 2-acetylphenyl and the like.

- 5 "Heteroaryl acyl" refers to heteroaryl groups having an acyl substituent, including 2-acetylpyridyl and the like.

"C<sub>3</sub>-C<sub>8</sub>-(hetero)cycloalkyl acyl" refers to 3 to 8 membered cycloalkyl or heterocycloalkyl groups having an acyl substituent.

- 10 "Acyloxy" refers to the group -OC(O)R where R includes H, "C<sub>1</sub>-C<sub>6</sub>-alkyl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl", "C<sub>2</sub>-C<sub>6</sub>-alkynyl", "C<sub>3</sub>-C<sub>8</sub>-cycloalkyl", heterocycloalkyl, "heterocycloalkyl", "aryl", "heteroaryl", "C<sub>1</sub>-C<sub>6</sub>-alkyl aryl" or "C<sub>1</sub>-C<sub>6</sub>-alkyl heteroaryl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl aryl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl heteroaryl", "C<sub>2</sub>-C<sub>6</sub>-alkynyl aryl", "C<sub>2</sub>-C<sub>6</sub>-alkynyl heteroaryl", "C<sub>1</sub>-C<sub>6</sub>-alkyl cycloalkyl", "C<sub>1</sub>-C<sub>6</sub>-alkyl heterocycloalkyl".

- 15 "C<sub>1</sub>-C<sub>6</sub>-alkyl acyloxy" refers to C<sub>1</sub>-C<sub>6</sub>-alkyl groups having an acyloxy substituent, including 2-(acetyloxy)ethyl and the like.

"Alkoxy" refers to the group -O-R where R includes "C<sub>1</sub>-C<sub>6</sub>-alkyl" or "aryl" or "heteroaryl" or "C<sub>1</sub>-C<sub>6</sub>-alkyl aryl" or "C<sub>1</sub>-C<sub>6</sub>-alkyl heteroaryl". Preferred alkoxy groups include by way of example, methoxy, ethoxy, phenoxy and the like.

- 20 "C<sub>1</sub>-C<sub>6</sub>-alkyl alkoxy" refers to C<sub>1</sub>-C<sub>6</sub>-alkyl groups having an alkoxy substituent, including 2-ethoxyethyl and the like.

"Alkoxycarbonyl" refers to the group -C(O)OR where R includes H, "C<sub>1</sub>-C<sub>6</sub>-alkyl" or "aryl" or "heteroaryl" or "C<sub>1</sub>-C<sub>6</sub>-alkyl aryl" or "C<sub>1</sub>-C<sub>6</sub>-alkyl heteroaryl".

"C<sub>1</sub>-C<sub>6</sub>-alkyl alkoxycarbonyl" refers to C<sub>1</sub>-C<sub>5</sub>-alkyl groups having an alkoxycarbonyl substituent, including 2-(benzyloxycarbonyl)ethyl and the like.

"Aminocarbonyl" refers to the group  $-C(O)NRR'$  where each R, R' includes independently hydrogen or C<sub>1</sub>-C<sub>6</sub>-alkyl or aryl or heteroaryl or "C<sub>1</sub>-C<sub>6</sub>-alkyl aryl" or "C<sub>1</sub>-C<sub>6</sub>-alkyl hetero-aryl".

5 "C<sub>1</sub>-C<sub>6</sub>-alkyl aminocarbonyl" refers to C<sub>1</sub>-C<sub>6</sub>-alkyl groups having an aminocarbonyl substituent, including 2-(dimethylaminocarbonyl)ethyl and the like.

"Acylamino" refers to the group  $-NRC(O)R'$  where each R, R' is independently hydrogen, "C<sub>1</sub>-C<sub>6</sub>-alkyl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl", "C<sub>2</sub>-C<sub>6</sub>-alkynyl", "C<sub>3</sub>-C<sub>8</sub>-cycloalkyl", "heterocycloalkyl", "aryl", "heteroaryl", "C<sub>1</sub>-C<sub>6</sub>-alkyl aryl" or "C<sub>1</sub>-C<sub>6</sub>-alkyl heteroaryl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl aryl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl heteroaryl", "C<sub>2</sub>-C<sub>6</sub>-alkynyl aryl", "C<sub>2</sub>-C<sub>6</sub>-alkynylheteroaryl", "C<sub>1</sub>-C<sub>6</sub>-alkyl  
10 cycloalkyl", "C<sub>1</sub>-C<sub>6</sub>-alkyl heterocycloalkyl".

"C<sub>1</sub>-C<sub>6</sub>-alkyl acylamino" refers to C<sub>1</sub>-C<sub>6</sub>-alkyl groups having an acylamino substituent, including 2-(propionylamino)ethyl and the like.

"Ureido" refers to the group  $-NRC(O)NR'R''$  where each R, R', R'' is independently hydrogen, "C<sub>1</sub>-C<sub>6</sub>-alkyl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl", "C<sub>2</sub>-C<sub>6</sub>-alkynyl", "C<sub>3</sub>-C<sub>8</sub>-cycloalkyl",  
15 "heterocycloalkyl", "aryl", "heteroaryl", "C<sub>1</sub>-C<sub>6</sub>-alkyl aryl" or "C<sub>1</sub>-C<sub>6</sub>-alkyl heteroaryl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl aryl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl heteroaryl", "C<sub>2</sub>-C<sub>6</sub>-alkynyl aryl", "C<sub>2</sub>-C<sub>6</sub>-alkynylheteroaryl", "C<sub>1</sub>-C<sub>6</sub>-alkyl cycloalkyl", "C<sub>1</sub>-C<sub>6</sub>-alkyl heterocycloalkyl", and where R' and R'', together with the nitrogen atom to which they are attached, can optionally form a 3-8-membered heterocycloalkyl ring.

20 "C<sub>1</sub>-C<sub>6</sub>-alkyl ureido" refers to C<sub>1</sub>-C<sub>6</sub>-alkyl groups having an ureido substituent, including 2-(*N*'-methy lureido)ethyl and the like.

"Carbamate" refers to the group  $-NRC(O)OR'$  where each R, R' is independently hydrogen, "C<sub>1</sub>-C<sub>6</sub>-alkyl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl", "C<sub>2</sub>-C<sub>6</sub>-alkynyl", "C<sub>3</sub>-C<sub>8</sub>-cycloalkyl", "heterocycloalkyl", "aryl", "heteroaryl", "C<sub>1</sub>-C<sub>6</sub>-alkyl aryl" or "C<sub>1</sub>-C<sub>6</sub>-alkyl heteroaryl",  
25 "C<sub>2</sub>-C<sub>6</sub>-alkenyl aryl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl heteroaryl", "C<sub>2</sub>-C<sub>6</sub>-alkynyl aryl", "C<sub>2</sub>-C<sub>6</sub>-alkynylheteroaryl", "C<sub>1</sub>-C<sub>6</sub>-alkyl cycloalkyl", "C<sub>1</sub>-C<sub>6</sub>-alkyl heterocycloalkyl".

"Amino" refers to the group  $-NRR'$  where each  $R, R'$  is independently hydrogen or "C<sub>1</sub>-C<sub>6</sub>-alkyl" or "aryl" or "heteroaryl" or "C<sub>1</sub>-C<sub>6</sub>-alkyl aryl" or "C<sub>1</sub>-C<sub>6</sub>-alkyl heteroaryl", or "cycloalkyl", or "heterocycloalkyl", and where R and R', together with the nitrogen atom to which they are attached, can optionally form a 3-8-membered heterocycloalkyl ring.

- 5 "C<sub>1</sub>-C<sub>6</sub>-alkyl amino" refers to C<sub>1</sub>-C<sub>5</sub>-alkyl groups having an amino substituent, including 2-(1-pyrrolidinyl)ethyl and the like.

"Ammonium" refers to a positively charged group  $-N^+RR'R''$ , where each  $R, R', R''$  is independently "C<sub>1</sub>-C<sub>6</sub>-alkyl" or "C<sub>1</sub>-C<sub>6</sub>-alkyl aryl" or "C<sub>1</sub>-C<sub>6</sub>-alkyl heteroaryl", or "cycloalkyl", or "heterocycloalkyl", and where R and R', together with the nitrogen atom  
10 to which they are attached, can optionally form a 3-8-membered heterocycloalkyl ring.

"C<sub>1</sub>-C<sub>6</sub>-alkyl ammonium" refers to C<sub>1</sub>-C<sub>6</sub>-alkyl groups having an ammonium substituent, including 2-(1-pyrrolidinyl)ethyl and the like.

"Halogen" refers to fluoro, chloro, bromo and iodo atoms.

"Sulfonyloxy" refers to a group  $-OSO_2-R$  wherein R is selected from H, "C<sub>1</sub>-C<sub>6</sub>-alkyl",  
15 "C<sub>1</sub>-C<sub>6</sub>-alkyl" substituted with halogens, *e.g.*, an  $-OSO_2-CF_3$  group, "C<sub>2</sub>-C<sub>6</sub>-alkenyl", "C<sub>2</sub>-C<sub>6</sub>-alkynyl", "C<sub>3</sub>-C<sub>8</sub>-cycloalkyl", "heterocycloalkyl", "aryl", "heteroaryl", "C<sub>1</sub>-C<sub>6</sub>-alkyl aryl" or "C<sub>1</sub>-C<sub>6</sub>-alkyl heteroaryl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl aryl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl heteroaryl", "C<sub>2</sub>-C<sub>6</sub>-alkynyl aryl", "C<sub>2</sub>-C<sub>6</sub>-alkynylheteroaryl", "C<sub>1</sub>-C<sub>6</sub>-alkyl cycloalkyl", "C<sub>1</sub>-C<sub>6</sub>-alkyl heterocycloalkyl".

- 20 "C<sub>1</sub>-C<sub>6</sub>-alkyl sulfonyloxy" refers to C<sub>1</sub>-C<sub>5</sub>-alkyl groups having a sulfonyloxy substituent, including 2-(methylsulfonyloxy)ethyl and the like.

"Sulfonyl" refers to group  $-SO_2-R$  wherein R is selected from H, "aryl", "heteroaryl", "C<sub>1</sub>-C<sub>6</sub>-alkyl", "C<sub>1</sub>-C<sub>6</sub>-alkyl" substituted with halogens, *e.g.*, an  $-SO_2-CF_3$  group, "C<sub>2</sub>-C<sub>6</sub>-alkenyl", "C<sub>2</sub>-C<sub>6</sub>-alkynyl", "C<sub>3</sub>-C<sub>8</sub>-cycloalkyl", "heterocycloalkyl", "aryl", "heteroaryl",  
25 "C<sub>1</sub>-C<sub>6</sub>-alkyl aryl" or "C<sub>1</sub>-C<sub>6</sub>-alkyl heteroaryl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl aryl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl

heteroaryl", "C<sub>2</sub>-C<sub>6</sub>-alkynyl aryl", "C<sub>2</sub>-C<sub>6</sub>-alkynylheteroaryl", "C<sub>1</sub>-C<sub>6</sub>-alkyl cycloalkyl", "C<sub>1</sub>-C<sub>6</sub>-alkyl heterocycloalkyl".

"C<sub>1</sub>-C<sub>6</sub>-alkyl sulfonyl" refers to C<sub>1</sub>-C<sub>5</sub>-alkyl groups having a sulfonyl substituent, including 2-(methylsulfonyl)ethyl and the like.

5 "Sulfinyl" refers to a group "-S(O)-R" wherein R is selected from H, "C<sub>1</sub>-C<sub>6</sub>-alkyl", "C<sub>1</sub>-C<sub>6</sub>-alkyl" substituted with halogens, *e.g.*, a -SO-CF<sub>3</sub> group, "C<sub>2</sub>-C<sub>6</sub>-alkenyl", "C<sub>2</sub>-C<sub>6</sub>-alkynyl", "C<sub>3</sub>-C<sub>8</sub>-cycloalkyl", "heterocycloalkyl", "aryl", "heteroaryl", "C<sub>1</sub>-C<sub>6</sub>-alkyl aryl" or "C<sub>1</sub>-C<sub>6</sub>-alkyl heteroaryl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl aryl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl heteroaryl", "C<sub>2</sub>-C<sub>6</sub>-alkynyl aryl", "C<sub>2</sub>-C<sub>6</sub>-alkynylheteroaryl", "C<sub>1</sub>-C<sub>6</sub>-alkyl cycloalkyl", "C<sub>1</sub>-C<sub>6</sub>-alkyl  
10 heterocycloalkyl".

"C<sub>1</sub>-C<sub>6</sub>-alkyl sulfinyl" refers to C<sub>1</sub>-C<sub>5</sub>-alkyl groups having a sulfinyl substituent, including 2-(methylsulfinyl)ethyl and the like.

"Sulfanyl" refers to groups -S-R where R includes H, "C<sub>1</sub>-C<sub>6</sub>-alkyl", "C<sub>1</sub>-C<sub>6</sub>-alkyl" substituted with halogens, *e.g.*, an -SO-CF<sub>3</sub> group, "C<sub>2</sub>-C<sub>6</sub>-alkenyl", "C<sub>2</sub>-C<sub>6</sub>-alkynyl", "C<sub>3</sub>-C<sub>8</sub>-cycloalkyl", "heterocycloalkyl", "aryl", "heteroaryl", "C<sub>1</sub>-C<sub>6</sub>-alkyl aryl" or "C<sub>1</sub>-C<sub>6</sub>-alkyl heteroaryl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl aryl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl heteroaryl", "C<sub>2</sub>-C<sub>6</sub>-alkynyl aryl", "C<sub>2</sub>-C<sub>6</sub>-alkynylheteroaryl", "C<sub>1</sub>-C<sub>6</sub>-alkyl cycloalkyl", "C<sub>1</sub>-C<sub>6</sub>-alkyl heterocycloalkyl".  
15 Preferred sulfanyl groups include methylsulfanyl, ethylsulfanyl, and the like.

"C<sub>1</sub>-C<sub>6</sub>-alkyl sulfanyl" refers to C<sub>1</sub>-C<sub>5</sub>-alkyl groups having a sulfanyl substituent, including  
20 2-(ethylsulfanyl)ethyl and the like.

"Sulfonylamino" refers to a group -NRSO<sub>2</sub>-R' where each R, R' includes independently hydrogen, "C<sub>1</sub>-C<sub>6</sub>-alkyl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl", "C<sub>2</sub>-C<sub>6</sub>-alkynyl", "C<sub>3</sub>-C<sub>8</sub>-cycloalkyl", "heterocycloalkyl", "aryl", "heteroaryl", "C<sub>1</sub>-C<sub>6</sub>-alkyl aryl" or "C<sub>1</sub>-C<sub>6</sub>-alkyl heteroaryl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl aryl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl heteroaryl", "C<sub>2</sub>-C<sub>6</sub>-alkynyl aryl", "C<sub>2</sub>-C<sub>6</sub>-alkynylheteroaryl", "C<sub>1</sub>-C<sub>6</sub>-alkyl cycloalkyl", "C<sub>1</sub>-C<sub>6</sub>-alkyl heterocycloalkyl".  
25



"C<sub>1</sub>-C<sub>6</sub>-alkyl sulfonylamino" refers to C<sub>1</sub>-C<sub>5</sub>-alkyl groups having a sulfonylamino substituent, including 2-(ethylsulfonylamino)ethyl and the like.

"Aminosulfonyl" refers to a group -SO<sub>2</sub>-NRR' where each R, R' includes independently hydrogen, "C<sub>1</sub>-C<sub>6</sub>-alkyl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl", "C<sub>2</sub>-C<sub>6</sub>-alkynyl", "C<sub>3</sub>-C<sub>8</sub>-cycloalkyl", "heterocycloalkyl", "aryl", "heteroaryl", "C<sub>1</sub>-C<sub>6</sub>-alkyl aryl" or "C<sub>1</sub>-C<sub>6</sub>-alkyl heteroaryl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl aryl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl heteroaryl", "C<sub>2</sub>-C<sub>6</sub>-alkynyl aryl", "C<sub>2</sub>-C<sub>6</sub>-alkynylheteroaryl", "C<sub>1</sub>-C<sub>6</sub>-alkyl cycloalkyl", "C<sub>1</sub>-C<sub>6</sub>-alkyl heterocycloalkyl".

"C<sub>1</sub>-C<sub>6</sub>-alkyl aminosulfonyl" refers to C<sub>1</sub>-C<sub>6</sub>-alkyl groups having an aminosulfonyl substituent, including 2-(cyclohexylaminosulfonyl)ethyl and the like.

10 "Substituted or unsubstituted": Unless otherwise constrained by the definition of the individual substituent, the above set out groups, like "alkyl", "alkenyl", "alkynyl", "aryl" and "heteroaryl" etc. groups can optionally be substituted with from 1 to 5 substituents selected from the group consisting of "C<sub>1</sub>-C<sub>6</sub>-alkyl", "C<sub>2</sub>-C<sub>6</sub>-alkenyl", "C<sub>2</sub>-C<sub>6</sub>-alkynyl", "cycloalkyl", "heterocycloalkyl", "C<sub>1</sub>-C<sub>6</sub>-alkyl aryl", "C<sub>1</sub>-C<sub>6</sub>-alkyl heteroaryl", "C<sub>1</sub>-C<sub>6</sub>-alkyl cycloalkyl", "C<sub>1</sub>-C<sub>6</sub>-alkyl heterocycloalkyl", "amino", "ammonium", "acyl", "acyloxy", "acylamino", "aminocarbonyl", "alkoxycarbonyl", "ureido", "aryl", "carbamate", "heteroaryl", "sulfinyl", "sulfonyl", "alkoxy", "sulfanyl", "halogen", "carboxy", trihalomethyl, cyano, hydroxy, mercapto, nitro, and the like. Alternatively said substitution could also comprise situations where neighbouring substituents have undergone ring closure, notably when vicinal functional substituents are involved, thus forming, *e.g.*, lactams, lactons, cyclic anhydrides, but also acetals, thioacetals, amins formed by ring closure for instance in an effort to obtain a protective group.

25 "Pharmaceutically acceptable cationic salts or complexes" is intended to define such salts as the alkali metal salts, (*e.g.* sodium and potassium), alkaline earth metal salts (*e.g.* calcium or magnesium), aluminium salts, ammonium salts and salts with organic amines such as with methylamine, dimethylamine, trimethylamine, ethylamine, triethylamine, morpholine, N-Me-D-glucamine, N,N'-bis(phenylmethyl)-1,2-ethanediamine,

ethanolamine, diethanolamine, ethylenediamine, N-methylmorpholine, piperidine, benzathine (N,N'-dibenzylethylenediamine), choline, ethylene-diamine, meglumine (N-methylglucamine), benethamine (N-benzylphenethylamine), diethylamine, piperazine, thromethamine (2-amino-2-hydroxymethyl-1,3-propanediol), procaine as well as amines of  
5 formula  $-NR,R',R''$  wherein R, R', R'' is independently hydrogen, alkyl or benzyl. Especially preferred salts are sodium and potassium salts.

"Pharmaceutically acceptable salts or complexes" refers to salts or complexes of the below-identified compounds of formulae (I), (I'), (Ia), (Ib), (Ic), (Id), (II) or (III) that retain the desired biological activity. Examples of such salts include, but are not restricted to acid  
10 addition salts formed with inorganic acids (*e.g.*, hydrochloric acid, hydrobromic acid, sulfuric acid, phosphoric acid, nitric acid, and the like), and salts formed with organic acids such as acetic acid, oxalic acid, tartaric acid, succinic acid, malic acid, fumaric acid, maleic acid, ascorbic acid, benzoic acid, tannic acid, pamoic acid, alginic acid, polyglutamic acid, naphthalene sulfonic acid, naphthalene disulfonic acid, and poly-galacturonic acid. Said  
15 compounds can also be administered as pharmaceutically acceptable quaternary salts known by a person skilled in the art, which specifically include the quaternary ammonium salt of the formula  $-NR,R',R''^+ Z^-$ , wherein R, R', R'' is independently hydrogen, alkyl, or benzyl, C<sub>1</sub>-C<sub>6</sub>-alkyl, C<sub>2</sub>-C<sub>6</sub>-alkenyl, C<sub>2</sub>-C<sub>6</sub>-alkynyl, C<sub>1</sub>-C<sub>6</sub>-alkyl aryl, C<sub>1</sub>-C<sub>6</sub>-alkyl heteroaryl, cycloalkyl, heterocycloalkyl, and Z is a counterion, including chloride,  
20 bromide, iodide, -O-alkyl, toluenesulfonate, methylsulfonate, sulfonate, phosphate, or carboxylate (such as benzoate, succinate, acetate, glycolate, maleate, malate, fumarate, citrate, tartrate, ascorbate, cinnamate, mandelate, and diphenylacetate).

"Pharmaceutically active derivative" refers to any compound that upon administration to the recipient, is capable of providing directly or indirectly, the activity disclosed herein.

25 "Enantiomeric excess" (ee) refers to the products that are obtained by an asymmetric synthesis, *i.e.* a synthesis involving non-racemic starting materials and/or reagents or a synthesis comprising at least one enantioselective step, whereby a surplus of one enantiomer in the order of at least about 52% ee is yielded.

"Spermatozoa" or "sperm (cells)" are used synonymously herein and relate to male gametes. "Semen" or "seminal fluid/liquid" contain sperm cells as well as seminal plasma.

"Increase of spermatozoa fertilization activity" refers to any enhancement, improvement, or change to the better of the parameters determining the quality or activity of the sperm cell, such as e.g. percentage curvilinear velocity (VCL), average path velocity (VAP),  
5 straight-line velocity (VSL) and hyperactivated sperm fraction (HA). The quality of the spermatozoa determines the fertilization rate in assisted reproduction techniques.

"Increase of spermatozoa motility" refers to any improvement, enhancement, amelioration or change to the better of the quality or fertilization activity or motility or velocity of the  
10 cells.

"Phosphatidylinositol-3-kinase" or "PI3K" refers to any member of the PI3K family, i.e. those related enzymes having the activity outlined in the introduction.

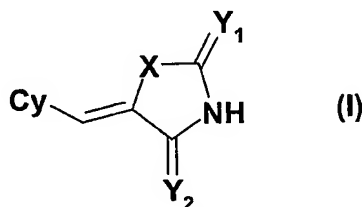
"Inhibitor of phosphatidylinositol-3-kinase" refers to as PI3K and inhibits the production of D-3 phosphoinositides in the cell. The term D-3 phosphoinositides is intended to  
15 encompass derivatives of phosphatidylinositol that are phosphorylated in the D-3 position of the inositol ring and comprises, for example, phosphatidylinositol(3)monophosphate (PI(3)P), phosphatidylinositol(3,4)bispophosphate (PI(3,4)P<sub>2</sub>) or phosphatidylinositol-(3,4,5)trisphosphate (PI(3,4,5)P<sub>3</sub>).

"Effective amount" refers to an amount of the active ingredients that is sufficient to  
20 affect the fertilization activity, in particular the mobility of spermatozoa. The effective amount will depend on the route of administration and the condition of the patient.

"Pharmaceutically acceptable" refers to any carrier, which does not interfere with the effectiveness of the biological activity of the active ingredient and that is not toxic to the host to which is administered. For example, for parenteral administration, the above  
25 active ingredients may be formulated in unit dosage form for injection in vehicles such as saline, dextrose solution, serum albumin and Ringer's solution. Besides the pharmaceutically acceptable carrier, the compositions of the invention can also

comprise minor amounts of common additives, such as stabilisers, excipients, buffers and preservatives.

According to the present invention, said process to improve the spermatozoa fertilization activity, in particular for increasing spermatozoa motility, comprises the step of treating  
5 spermatozoa with a compound of formula (I).



Formula (I) also comprises its geometrical isomers, its optically active forms as enantiomers, diastereomers and its racemate forms, as well as pharmaceutically acceptable salts and pharmaceutically active derivatives thereof. Preferred pharmaceutically acceptable salts of the formula (I) are acid addition salts formed with  
10 pharmaceutically acceptable acids, like hydrochloride, hydrobromide, sulfate or bisulfate, phosphate or hydrogen phosphate, acetate, benzoate, succinate, fumarate, maleate, lactate, citrate, tartrate, gluconate, methanesulfonate, benzenesulfonate, and *para*-toluenesulfonate salts.

15 The compounds of the present invention may be obtained as E/Z isomer mixture or as essentially pure E-isomers or Z isomers. The E/Z isomerism preferably refers to the vinyl moiety linking the phenyl with the azolidinone moiety. In a specific embodiment, the compounds of formula (I) are Z-isomers.

Such compounds of formula (I) may be used for the preparation of a pharmaceutical  
20 composition to improve the spermatozoa fertilization activity, in particular to increase spermatozoa motility and for the treatment of spermatozoa.

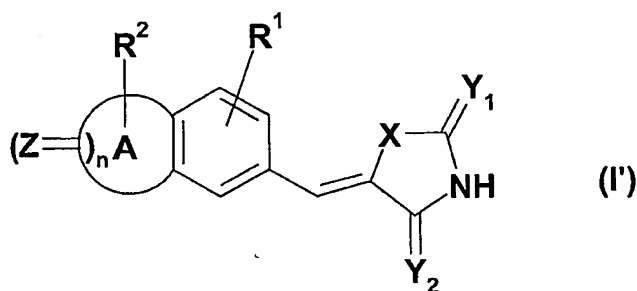
The substituents within formula (I) are defined as follows :

X is S, O or NH, preferably S.

$Y^1$  and  $Y^2$  are independently S, O or -NH, preferably O.

Cy is a substituted or unsubstituted 5 to 8 membered carbocyclic or heterocyclic group which may be optionally fused with an aryl, heteroaryl, cycloalkyl or heterocycloalkyl ring.

According to a more specific embodiment of the invention, the compounds of formula (I) have a fused phenyl moiety thus giving compounds of formula (I').



The substituents within formula (I') are defined as follows:

- 10 A is an unsubstituted or substituted 5-8 membered heterocyclic group or an unsubstituted or substituted carbocyclic group.

Said carbocyclic group may be fused with an unsubstituted or substituted aryl, an unsubstituted or substituted heteroaryl, an unsubstituted or substituted cycloalkyl or an unsubstituted or substituted heterocycloalkyl.

- 15 Such heterocyclic or carbocyclic groups comprise aryl, heteroaryl, cycloalkyl and heterocycloalkyl, including phenyl, phenantrenyl, cyclopentyl, cyclohexyl, norbornyl, pyrrolidine, piperidine, piperazine, 1-methylpiperazine, morpholine, pyrrolyl, furanyl, thienyl, imidazolyl, oxazolyl, isoxazolyl, thiazolyl, isothiazolyl, pyrazolyl, 1,2,3-triazolyl, 1,2,4-triazolyl, 1,2,3-oxadiazolyl, 1,2,4-oxadiazolyl, 1,2,5-oxadiazolyl, 1,3,4-oxadiazolyl, 1,3,4-triazinyl, 1,2,3-triazinyl, benzofuryl, [2,3-dihydro]benzofuryl, isobenzofuryl, benzothienyl, benzotriazolyl, isobenzothienyl, indolyl, isoindolyl, 3H-indolyl, benzimidazolyl, imidazo[1,2-a]pyridyl, benzothiazolyl, benzoxazolyl, quinoliziny,
- 20

quinazolinyl, phthalazinyl, quinoxalinyl, cinnolinyl, naphthyridinyl, pyrido[3,4-b]pyridyl, pyrido[3,2-b]pyridyl, pyrido[4,3-b]pyridyl, quinolyl, isoquinolyl, tetrazolyl, 5,6,7,8-tetrahydroquinolyl, 5,6,7,8-tetrahydroisoquinolyl, purinyl, pteridinyl, carbazolyl, xanthenyl or benzoquinolyl

- 5 Further exemplary heterocyclic or carbocyclic groups A include unsubstituted or substituted dioxol, unsubstituted or substituted dioxin, unsubstituted or substituted dihydrofuran, unsubstituted or substituted (dihydro) furanyl, unsubstituted or substituted (dihydro)oxazinyl, unsubstituted or substituted oxazinoyl, unsubstituted or substituted pyridinyl, unsubstituted or substituted isooxazolyl, unsubstituted or substituted oxazolyl
- 10 unsubstituted or substituted (dihydro)naphthalenyl, unsubstituted or substituted pyrimidinyl, unsubstituted or substituted triazolyl, unsubstituted or substituted imidazolyl, unsubstituted or substituted pyrazinyl, unsubstituted or substituted thiazolyl, unsubstituted or substituted thiadiazolyl, unsubstituted or substituted oxadiazolyl.

X is S, O or NH, preferably S.

- 15 Y<sup>1</sup> and Y<sup>2</sup> are independently from each other selected from the group consisting of S, O or -NH, preferably O.

Z is S or O, preferably O.

- R<sup>1</sup> is selected from the group comprising or consisting of H, CN, carboxy, acyl, C<sub>1</sub>-C<sub>6</sub>-alkoxy, halogen, hydroxy, acyloxy, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl carboxy, an
- 20 unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl acyloxy, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl alkoxy, alkoxycarbonyl, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl alkoxycarbonyl, aminocarbonyl, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl aminocarbonyl, acylamino, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl acylamino, ureido, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl ureido, amino, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl amino, ammonium,
- 25 sulfonyloxy, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl sulfonyloxy, sulfonyl, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl sulfonyl, sulfinyl, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl sulfinyl, sulfanyl, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl sulfanyl,

sulfonylamino, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl sulfonylamino or carbamate. In a specific embodiment R<sup>1</sup> is H.

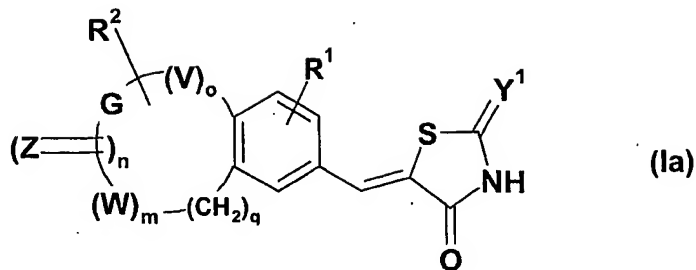
R<sup>2</sup> is selected from the group comprising or consisting of H, halogen, acyl, amino, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl, an unsubstituted or substituted C<sub>2</sub>-C<sub>6</sub>-alkenyl, an unsubstituted or substituted C<sub>2</sub>-C<sub>6</sub>-alkynyl, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl carboxy, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl acyl, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl alkoxycarbonyl, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl aminocarbonyl, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl acyloxy, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl acylamino, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl ureido, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl carbamate, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl amino, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl alkoxy, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl sulfanyl, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl sulfinyl, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl sulfonyl, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl sulfonylaminoaryl, aryl, an unsubstituted or substituted C<sub>3</sub>-C<sub>8</sub>-cycloalkyl or heterocycloalkyl, an unsubstituted or substituted C<sub>1</sub>-C<sub>6</sub>-alkyl aryl, an unsubstituted or substituted C<sub>2</sub>-C<sub>6</sub>-alkenyl-aryl, an unsubstituted or substituted C<sub>2</sub>-C<sub>6</sub>-alkynyl aryl, carboxy, cyano, hydroxy, C<sub>1</sub>-C<sub>6</sub>-alkoxy, nitro, acylamino, ureido, sulfonylamino, sulfanyl, or sulfonyl.

n is an integer 0, 1 or 2, preferably n is 0 or 1. Most preferred is n = 0.

According to a specific embodiment of the invention, R<sup>1</sup> and R<sup>2</sup> are both H.

, X is S, Y<sup>1</sup> and Y<sup>2</sup> are both O, R<sup>1</sup> and R<sup>2</sup> are as above defined and n is 0.

In a further specific embodiment according to the invention the compounds are of formula (Ia) :

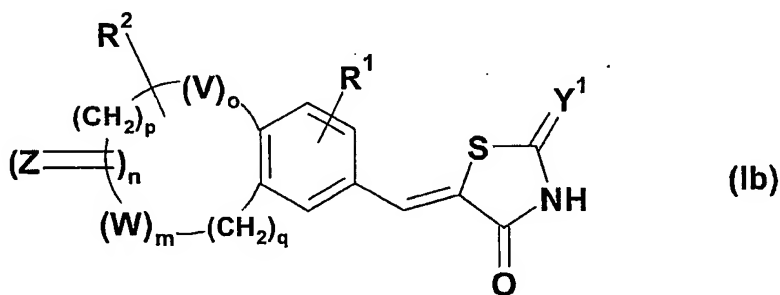


$R^1$ ,  $R^2$ ,  $Y^1$ ,  $Z$  and  $n$  in formula (Ia) are as above-defined.

$G$  in formula (Ia) is an unsubstituted or substituted  $C_1$ - $C_5$  alkylene (e.g. methylene, ethylene, propylene etc.) or an unsubstituted or substituted  $C_1$ - $C_5$  alkenylene group (e.g. a methine ( $-CH=$ ), a  $-CH=CH-$  group, a propenylene group, etc.).

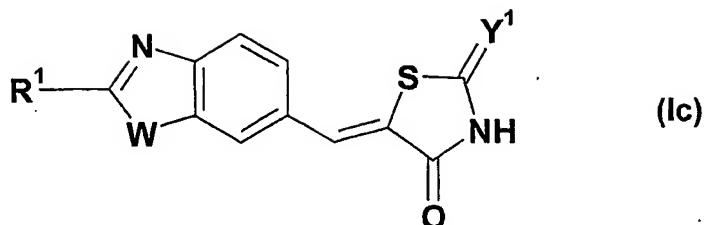
$W$  and  $V$  in formula (Ia) are each independently from each other selected from  $O$ ,  $S$ ,  $-NR^3$  wherein  $R^3$  is  $H$  or an unsubstituted or substituted  $C_1$ - $C_6$  alkyl group,  $m$  and  $o$  are each independently from each other 0 or 1;  $o$  is an integer from 1 to 4 and  $q$  is an integer from 0 to 4.

Even more preferred compounds of formula (Ia) is where  $G$  is an  $C_1$ - $C_4$  alkylene, thus giving compounds of formula (Ib) (i.e.  $p = 1, 2, 3$  or 4, preferably 1 or 2).

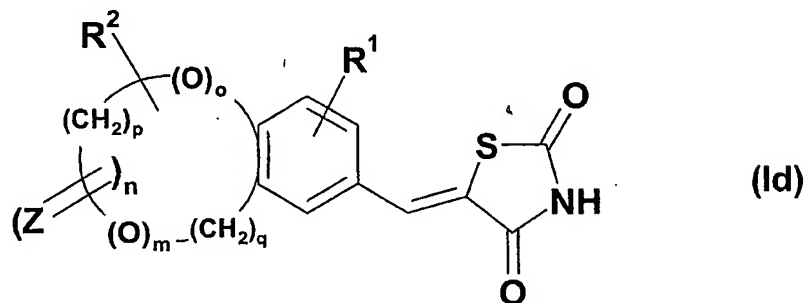


A specific sub-group of formula (Ib) are compounds having the formula (Ic), whereby  $W$ ,  $R^1$ ,  $Y^1$  are as above defined; specifically  $R^1$  may be an unsubstituted or substituted  $C_1$ - $C_4$  alkyl group or an unsubstituted or substituted  $C_1$ - $C_5$  alkenyl group, carboxy, cyano,  $C_1$ - $C_4$ -alkoxy, nitro, acylamino, ureido.





Still a further specific sub-group of formula (Ia) are compounds, wherein V, W and Y<sup>1</sup> are all O, thus providing compounds of formula (Id).



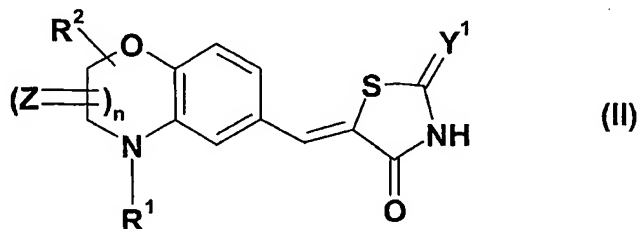
- 5 In a preferred embodiment of formulae (Ia), (Ib) or (Id), n is 0, m is 1, p is 1 or 2, o is 0, q is 1, and R<sup>1</sup> and R<sup>2</sup> are as above-defined.

In a further specific embodiment of formulae (Ia), (Ib) or (Id), m is 1, n is 0, p is 1 or 2, q is 0, o is 1 while R<sup>1</sup> and R<sup>2</sup> are as above-defined, more particularly R<sup>1</sup> is halogen or a hydrogen atom.

- 10 In another specific embodiment of formula (Ia), (Ib) or (Id), p is 1 or 2, q is 0, m is 0, n is 1 and R<sup>1</sup> and R<sup>2</sup> are as above-defined.

A further aspect of the invention consists in the use thiazolidindione-vinyl fused-benzene derivatives of formula (II-a)

More specific thiazolidinone-vinyl fused-benzene derivatives are of formula (II)

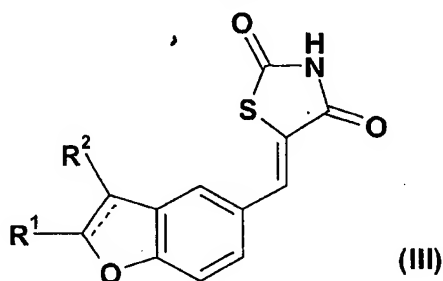


wherein Y<sup>1</sup>, Z, R<sup>1</sup>, R<sup>2</sup> are as above defined and n is 0 or 1.

In a specific embodiment  $R^1$  is an unsubstituted or substituted  $C_1$ - $C_6$ -alkyl, an unsubstituted or substituted  $C_1$ - $C_6$ -alkyl aryl, an unsubstituted or substituted aryl, an unsubstituted or substituted  $C_3$ - $C_8$ -cycloalkyl or -heterocycloalkyl, an unsubstituted or substituted  $C_1$ - $C_6$ -alkyl aryl, an unsubstituted or substituted  $C_2$ - $C_6$ -alkenyl-aryl, an  
 5 unsubstituted or substituted  $C_2$ - $C_6$ -alkynyl aryl.

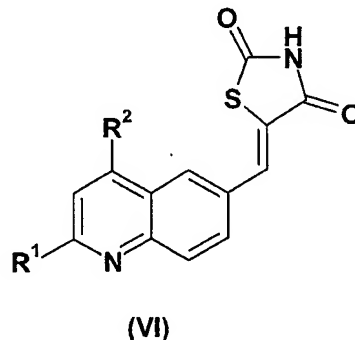
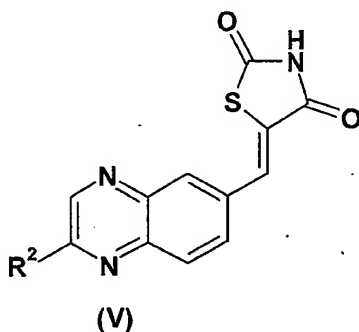
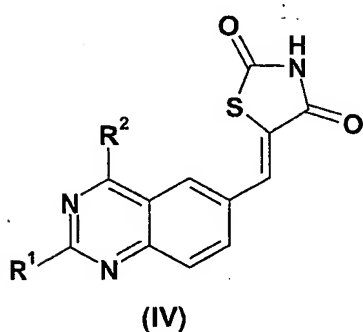
In another preferred embodiment according to the present invention  $Y^1$  is O.

More specific thiazolidinone-vinyl fused-benzene derivatives are of formula (III)



wherein  $R^1$  and  $R^2$  are as above defined.

10 More specific thiazolidinone-vinyl fused-benzene derivatives are of formulae (IV), (V) and (VI) :



$R^1$  is selected from the group consisting of hydrogen, halogen, cyano,  $C_1$ - $C_6$ -alkyl,  $C_1$ - $C_6$ -alkoxy, acyl, alkoxy carbonyl, while  $R^2$  is as above defined. In a specific embodiment  $R^2$  is  
 15 an amino moiety.

The compounds of the present invention are suitable for the modulation, notably the inhibition of the activity of phosphatoinositides 3-kinases (PI3K), particularly

phosphatoinositides 3-kinase (PI3K $\gamma$ ). It is therefore believed that the compounds of the present invention are also particularly useful for increasing the sperm motility.

A preferred aspect according to the invention is the one wherein the compounds of formula (I) are selected from the group consisting of:

- 5-(1,3-benzodioxol-5-ylmethylene)-1,3-thiazolidine-2,4-dione
- 5-(1,3-benzodioxol-5-ylmethylene)-2-thioxo-1,3-thiazolidin-4-one
- 5-(2,3-dihydro-1,4-benzodioxin-6-ylmethylene)-1,3-thiazolidine-2,4-dione
- 5-(2,3-dihydro-1-benzofuran-5-ylmethylene)-1,3-thiazolidine-2,4-dione
- 5-[(7-methoxy-1,3-benzodioxol-5-yl)methylene]-1,3-thiazolidine-2,4-dione
- 5-[(9,10-dioxo-9,10-dihydroanthracen-2-yl)methylene]-1,3-thiazolidine-2,4-dione
- 5-[(2,2-difluoro-1,3-benzodioxol-5-yl)methylene]-1,3-thiazolidine-2,4-dione
- (5Z)-5-(1,3-dihydro-2-benzofuran-5-ylmethylene)-1,3-thiazolidine-2,4-dione
- 5-(1-benzofuran-5-ylmethylene)-1,3-thiazolidine-2,4-dione
- 5-[(4-methyl-3-oxo-3,4-dihydro-2H-1,4-benzoxazin-6-yl)methylene]-1,3-thiazolidine-2,4-dione
- 5-(1,3-benzodioxol-5-ylmethylene)-2-imino-1,3-thiazolidin-4-one
- 5-Quinolin-6-ylmethylene-thiazolidine-2,4-dione
- 5-Quinolin-6-ylmethylene-2-thioxo-thiazolidin-4-one
- 2-Imino-5-quinolin-6-ylmethylene-thiazolidin-4-one
- 5-(3-Methyl-benzo[d]isoxazol-5-ylmethylene)-thiazolidine-2,4-dione
- 5-(4-Phenyl-quinazolin-6-ylmethylene)-thiazolidine-2,4-dione
- 5-(4-Dimethylamino-quinazolin-6-ylmethylene)-thiazolidine-2,4-dione
- 5-[(4-aminoquinazolin-6-yl)methylene]-1,3-thiazolidine-2,4-dione
- 5-[(4-piperidin-1-ylquinazolin-6-yl)methylene]-1,3-thiazolidine-2,4-dione
- 5-[(4-morpholin-4-ylquinazolin-6-yl)methylene]-1,3-thiazolidine-2,4-dione
- 5-[[4-(benzylamino)quinazolin-6-yl]methylene]-1,3-thiazolidine-2,4-dione

5-{[4-(diethylamino)quinazolin-6-yl]methylene}-1,3-thiazolidine-2,4-dione

5-({4-[(pyridin-2-ylmethyl)amino]quinazolin-6-yl}methylene)-1,3-thiazolidine-2,4-dione

5-({4-[(pyridin-3-ylmethyl)amino]quinazolin-6-yl}methylene)-1,3-thiazolidine-2,4-dione

ethyl 1-{6-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]quinazolin-4-yl}piperidine-3-carboxylate

ethyl 1-{6-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]quinazolin-4-yl}piperidine-4-carboxylate

tert-butyl 1-{6-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]quinazolin-4-yl}-L-prolinate

5-{[4-(4-methylpiperazin-1-yl)quinazolin-6-yl]methylene}-1,3-thiazolidine-2,4-dione

5-{[4-(4-pyrimidin-2-ylpiperazin-1-yl)quinazolin-6-yl]methylene}-1,3-thiazolidine-2,4-dione

5-({4-[4-(4-fluorophenyl)piperidin-1-yl]quinazolin-6-yl}methylene)-1,3-thiazolidine-2,4-dione

5-{[4-(4-benzylpiperidin-1-yl)quinazolin-6-yl]methylene}-1,3-thiazolidine-2,4-dione

5-({4-[4-(2-phenylethyl)piperidin-1-yl]quinazolin-6-yl}methylene)-1,3-thiazolidine-2,4-dione

5-{[4-(4-methylpiperidin-1-yl)quinazolin-6-yl]methylene}-1,3-thiazolidine-2,4-dione

5-{[4-(4-hydroxypiperidin-1-yl)quinazolin-6-yl]methylene}-1,3-thiazolidine-2,4-dione

1-[6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-quinazolin-4-yl]-piperidine-4-carboxylic acid

1-[6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-quinazolin-4-yl]-piperidine-3-carboxylic acid

1-[6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-quinazolin-4-yl]-pyrrolidine-2-carboxylic acid

5-(4-Methylamino-quinazolin-6-ylmethylene)-thiazolidine-2,4-dione

5-(4-Methoxy-quinazolin-6-ylmethylene)-thiazolidine-2,4-dione

2-Imino-5-(4-methylamino-quinazolin-6-ylmethylene)-thiazolidin-4-one

2-Imino-5-(4-piperidine-quinazolin-6-ylmethylene)-thiazolidin-4-one

2-Imino-5-(4-dimethylamino-quinazolin-6-ylmethylene)-thiazolidin-4-one

5-(2-Methyl-2H-benzotriazol-5-ylmethylene)-thiazolidine-2,4-dione

5-(3-Methyl-3H-benzotriazol-5-ylmethylene)-thiazolidine-2,4-dione

5-(3-Ethyl-3H-benzoimidazol-5-ylmethylene)-thiazolidine-2,4-dione

5-([1-(4-phenylbutyl)-1H-benzimidazol-6-yl]methylene)-1,3-thiazolidine-2,4-dione

5-[(1-prop-2-yn-1-yl-1H-benzimidazol-6-yl)methylene]-1,3-thiazolidine-2,4-dione

5-[(1-{2-[4-(trifluoromethyl)phenyl]ethyl}-1H-benzimidazol-6-yl)methylene]-1,3-thiazolidine-2,4-dione

5-({1-[2-(4-hydroxyphenyl)ethyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione

methyl 4-{6-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1H-benzimidazol-1-yl}cyclohexanecarboxylate

5-({1-[2-(5-methoxy-1H-indol-3-yl)ethyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione

5-({1-[(1-methyl-1H-pyrazol-4-yl)methyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione

5-({1-[2-(3,4-dimethoxyphenyl)ethyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione

5-({1-[2-(4-phenoxyphenyl)ethyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione

5-({1-[4-(trifluoromethyl)benzyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione

4-{6-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1H-benzimidazol-1-yl}cyclohexanecarboxylic acid

5-[(1-isobutyl-1H-benzimidazol-6-yl)methylene]-1,3-thiazolidine-2,4-dione

5-({1-[2-(1,3-benzodioxol-4-yl)ethyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione

5-({1-[2-(2-phenoxyphenyl)ethyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione

5-([1-(3,3-diphenylpropyl)-1H-benzimidazol-6-yl]methylene)-1,3-thiazolidine-2,4-dione

5-([1-(2-methoxybenzyl)-1H-benzimidazol-6-yl]methylene)-1,3-thiazolidine-2,4-dione

5-([1-(3-furylmethyl)-1H-benzimidazol-6-yl]methylene)-1,3-thiazolidine-2,4-dione

5-[(1-propyl-1H-benzimidazol-6-yl)methylene]-1,3-thiazolidine-2,4-dione

5-Quinoxalin-6-ylmethylene-thiazolidine-2,4-dione

5-Quinoxalin-6-ylmethylene-2-thioxo-thiazolidin-4-one

2-Imino-5-quinoxalin-6-ylmethylene-thiazolidin-4-one

5-Benzothiazol-6-ylmethylene-thiazolidine-2,4-dione

5-(3-Methyl-benzofuran-5-ylmethylene)-thiazolidine-2,4-dione

5-(2-Bromo-3-methyl-benzofuran-5-ylmethylene)-thiazolidine-2,4-dione

5-(3-bromo-benzofuran-5-ylmethylene)-thiazolidine-2,4-dione

3-[5-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-benzofuran-3-yl]-acrylic acid ethyl ester

3-[5-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-benzofuran-3-yl]-acrylic acid

5-[3-(3-Oxo-3-piperidin-1-yl-propenyl)-benzofuran-5-ylmethylene]-thiazolidine-2,4-dione

Methyl 1-((3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}prop-2-enoyl)prolinate

Methyl 1-((3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}prop-2-enoyl)-D-prolinate

(5-({3-[(3-oxo-3-pyrrolidin-1-ylprop-1-en-1-yl)-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione

5-({3-[3-morpholin-4-yl-3-oxoprop-1-en-1-yl]-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione

Methyl 1-(3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}prop-2-enoyl)-L-prolinate

N-cyclohexyl-3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}-N-methylacrylamide

3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}-N-ethyl-N-(2-hydroxyethyl)acrylamide

N-cyclobutyl-3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}acrylamide

5-({3-[3-azetidin-1-yl-3-oxoprop-1-en-1-yl]-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione

5-({3-[3-(1,3-dihydro-2H-isoindol-2-yl)-3-oxoprop-1-en-1-yl]-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione

5-({3-[3-azepan-1-yl-3-oxoprop-1-en-1-yl]-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione

3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}-N-piperidin-1-ylacrylamide

3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}-N-(pyridin-3-ylmethyl)acrylamide

N-cyclohexyl-3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}acrylamide

5-({3-[3-(4-methylpiperazin-1-yl)-3-oxoprop-1-en-1-yl]-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione

N-cycloheptyl-3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}acrylamide

5-({3-[3-(2,5-dihydro-1H-pyrrol-1-yl)-3-oxoprop-1-en-1-yl]-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione

N-cyclopentyl-3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}acrylamide

3-[5-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-benzofuran-3-yl]-propionic acid ethyl ester

3-[5-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-benzofuran-3-yl]-propionic acid

5-[3-(3-Oxo-3-piperidin-1-yl-propyl)-benzofuran-5-ylmethylene]-thiazolidine-2,4-dione

6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-2,3-dihydro-benzo[1,4]oxazine-4-carboxylic acid tert-butyl ester

5-(3,4-Dihydro-2H-benzo[1,4]oxazin-6-ylmethylene)-thiazolidine-2,4-dione

5-(4-Benzoyl-3,4-dihydro-2H-benzo[1,4]oxazin-6-ylmethylene)-thiazolidine-2,4-dione

5-(4-Acetyl-3,4-dihydro-2H-benzo[1,4]oxazin-6-ylmethylene)-thiazolidine-2,4-dione

6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-benzo[1,4]oxazine-4-carboxylic acid tert-butyl ester

[6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-3-oxo-2,3-dihydro-benzo[1,4]-oxazin-4-yl]-acetic acid methyl ester

N-Benzyl-2-[6-(2,4-dioxo-thiazolidin-5-ylidenemethyl)-3-oxo-2,3-dihydro-benzo[1,4]oxazin-4-yl]-acetamide

5-(4-Butyl-3-oxo-3,4-dihydro-2H-benzo[1,4]oxazin-6-ylmethylene)-thiazolidine-2,4-dione

5-(4-Benzyl-3-oxo-3,4-dihydro-2H-benzo[1,4]oxazin-6-ylmethylene)-thiazolidine-2,4-dione

5-(2-Chloro-benzofuran-5-ylmethylene)-thiazolidine-2,4-dione

5-(3-Amino-benzo[d]isoxazol-5-ylmethylene)-thiazolidine-2,4-dione

5-(3-Phenylethynyl-benzofuran-5-ylmethylene)-thiazolidine-2,4-dione

5-Benzo[1,2,5]thiadiazol-5-ylmethylene-thiazolidine-2,4-dione

5-Benzo[1,2,5]oxadiazol-5-ylmethylene-thiazolidine-2,4-dione

5-(2-Methyl-benzofuran-6-ylmethylene)-thiazolidine-2,4-dione

5-(2-Carboxymethyl-benzofuran-6-ylmethylene)-thiazolidine-2,4-dione

5-(3-Bromo-2-fluoro-2,3-dihydro-benzofuran-6-ylmethylene)-thiazolidine-2,4-dione

These agents have been shown to be particularly efficacious for the enhancement of sperm fertilization activity.

Preferably, the spermatozoa are treated with an amount of a compound of formula I in the range of about 0.01 to 1000  $\mu$ M, more preferably of about 5 to 500  $\mu$ M and most preferably of about 10 to 100  $\mu$ M. Treating the spermatozoa with a compound of formula (I) advantageously comprises incubating the spermatozoa for a period of time in the range of about 30 minutes to 10 hours, preferably about 1 to 8 hours, most preferably about 2 to 6 hours at a temperature of about 37°C.

The invention is based on the finding that phosphatidylinositol-3-kinase inhibitors have a pronounced positive effect on parameters determining sperm cell fertilization activity, i.e. the parameters relevant to the capacity of sperm cells to fertilize an oocyte. The most important factors involved in the ability to fertilize are the number of active sperms and the motility of the spermatozoa. According to the WHO manual, motility of 50% is considered the lower limit of normality.



It has now been found in accordance with the invention that the number of motile sperms obtainable from semen samples as well as the motility of the individual spermatozoa can be significantly increased by using compounds of formula (I). This effect is detectable in normospermic individuals. However, it is even more marked in spermatozoa displaying pathogenic features, like oligoasthenospermic patients, i.e. those patients having a reduced total number of spermatozoa and a reduced spermatozoa motility. The invention renders it possible to increase the percentage of spermatozoa with progressive motility, thus significantly improving the probability of successful fertilization. Thus, the process according to the invention helps patients avoid using ICSI in favor of less invasive ART, like conventional IVF.

In a preferred embodiment, treating the spermatozoa with a compound of formula (I) is performed on the seminal liquid comprising the spermatozoa. Performing the method according to the invention directly on the seminal liquid without any further treatment has the advantage that it is simple and fast. Since the PI3K inhibitor of the invention enhances sperm cell motility, removal of the seminal plasma is not necessary.

In a further preferred embodiment, the process further comprises separating the spermatozoa by spermatozoa separation methods used in assisted reproduction techniques (ART).

Since seminal plasma contains factors that inhibit capacitation and fertilization as well as a considerable amount of non-motile spermatozoa even in a fertile individual, it is advantageous to separate motile sperm cells from fluid, non-motile and morphologically defective spermatozoa. This step is essential in traditional ART like IVF, GIFT or Intra-uterine Insemination (IUI). It leads to an enhancement of the fertilization success rate also in the process according to the invention. It is evident from the examples that the increase in spermatozoa motility by using a compound of formula (I) is even more pronounced in spermatozoa which have been separated from the seminal plasma.

In a further preferred embodiment of the invention, separating the spermatozoa is performed by a method selected from the wash and spin method, the sedimentation

method, the direct swim-up method, the pellet and swim-up method, and the buoyant density gradient method. These methods are well known in the art. They are traditionally used in assisted reproduction techniques and described in detail in "A textbook of In Vitro Fertilization and Assisted Reproduction, The Bourn Hall guide to clinical and laboratory practice, editor: Peter R. Brinsden, The Parthenon Publishing Group" (1999) on pages 204  
5 to 208. This textbook is referred to hereinafter as the "Bourn Hall guide".

Preferably, separating the spermatozoa is performed by the direct swim-up method. This method implies self-selection of motile sperms, essentially comprising layering an aliquot of medium on top of a semen sample and allowing it to stand a room temperature for a  
10 certain period of time. The motile sperm cells will migrate into the top layer (medium), from which they can be recovered. The method may also include centrifugation step(s). The advantage of "swim-up" selected spermatozoa is that the motile cells present in the sample are isolated and concentrated and that the proportion of morphologically normal sperm is increased. It is shown in the examples that the process according to the invention  
15 leads to an increase of the amount of spermatozoa recovered from seminal fluid by the swim-up method. This is due to the increased motility of the sperms, which therefore migrate more quickly and in higher amounts into the upper phase of the sample.

The method may be varied and combined with further isolation/separation techniques, depending on the amount of motile cells in the sample. For example, the swim-up  
20 procedure may be performed through the layering of 1 ml of medium containing albumin on a 1 ml of underlying seminal liquid in a test tube. After one hour of incubation at 37°C in the air or in 5% CO<sub>2</sub> the upper phase of the medium to which the spermatozoa with better motility characteristics have migrated is collected. This technique may also comprise or be combined with a centrifugation step, for example centrifugation on Percoll gradients.  
25 The separated, isolated or enriched spermatozoa are then used in assisted-reproduction techniques or may be deep-frozen before being further processed, for example.

Advantageously, the incubation of spermatozoa with a compound of formula (I) is carried out on the seminal fluid, and then swim-up selection is performed. Thereafter, the

spermatozoa may be washed one or several times to eliminate the compound of formula (I), before being further processed for fertilization.

Preferably, the process according to the invention is performed on mammal spermatozoa, in particular on human spermatozoa.

5 The invention also relates to spermatozoa obtainable by the process described above. It is a further object of the invention to provide spermatozoa having an improved ability of fertilization. Therefore the invention further relates to spermatozoa in which the activity of the phosphatidylinositol-3 kinase is inhibited. The spermatozoa in which the a compound of formula (I) is inhibited or which were obtained in a process according to the invention  
10 exhibit an improved fertilization activity, a higher motility as compared to untreated sperm cells and thus exhibit a better performance with regard to fertilization.

As above-mentioned, sperm cell fertilization activity determines the fertilization rate in ART. The invention therefore further relates to the use of a compound of the above-mentioned formulae (I), (I'), (Ia), (Ib), (Ic), (Id), (II) or (III) for improving the fertilization  
15 rate in assisted reproduction techniques.

Any assisted reproduction method known in the art may be used according to the invention. In preferred embodiments, the assisted reproduction techniques are selected from in vitro fertilization (IVF), gamete intrafallopian transfer (GIFT), and intra-uterine insemination (IUI).

20 The invention further relates to the use of a compound of formula (I), (I'), (Ia), (Ib), (Ic), (Id), (II) or (III) for the preparation of a pharmaceutical composition for the treatment of infertility, in particular male infertility. While the invention is described in more detail for in vitro fertilization techniques, it will be appreciated by the person skilled in the art that the compound may be as efficient in terms of activity when administered *in vivo*.

25 In this case, the medicament is preferably presented in the form of a pharmaceutical composition comprising a compound of formula (I) together with one or more

pharmaceutically acceptable carriers and/or excipients. Such pharmaceutical compositions form yet a further aspect of the present invention.

The administration of such active ingredient may be by intravenous, intramuscular or subcutaneous route. Other routes of administration, which may establish the desired blood  
5 levels of the respective ingredients, are comprised by the present invention.

The invention further relates to the use of a compound of formula (I), (I'), (Ia), (Ib), (Ic), (Id), (II) and (III) for the preparation of a pharmaceutical composition for the improvement of spermatozoa fertilization activity, in particular for the increase of spermatozoa motility.

It is a further object of the present invention to provide for an improvement concerning the  
10 method of ART therapy. The improvement consists in including into known techniques for assisted fertilization a step comprising treating spermatozoa with a compound of formula (I). The further steps used in assisted reproduction techniques are well known to the person skilled in the art and can be taken from the WHO manual (supra) or the Bourn Hall guide (supra).

15 In a preferred embodiment of the invention, the ART are selected from in vitro fertilization (IVF), gamete intrafallopian transfer (GIFT), or intra-uterine insemination (IUI).

It is a further object of the present invention to provide a medium for storage and/or transportation of mammal spermatozoa, particular human spermatozoa, having improved qualities. The invention therefore also relates to a medium comprising a compound of  
20 formula (I). Apart from the a compound of formula (I), the medium may contain any further component known to be useful for storage and/or transportation, depending on the kind of storage and/or transportation required. For example, the spermatozoa may be stored at room temperature or by cryo-preservation. The latter is common for the storage of the cells for a longer period of time. Specific examples of further components of the medium  
25 can be taken e.g. from WO 97/16965. Further specific media suitable for cryopreservation of semen are included in Appendix II, pp. 541 and 542 of the Bourn Hall guide (supra), for

instance. They could be supplemented with a compound of formula (I) to improve the fertilization activity, in particular the motility of the sperm before fertilization takes place.

In a preferred embodiment, the medium comprises mammal spermatozoa, in particular human spermatozoa. Preferable, a compound of formula (I) present in the medium according to the invention is selected from the group consisting of (5-(2H-benzo[d]1,3-dioxolen-5-ylmethylene)-1,3-thiazolidine-2,4-dione and derivatives and analogues thereof. In a highly preferred embodiment, the compound of formula (I) is (5-(2H-benzo[d]1,3-dioxolen-5-ylmethylene)-1,3-thiazolidine-2,4-dione.

In yet a further preferred embodiment, the medium according to the invention comprises amounts of the compound of formula (I) in the range of about 0.01 to 1000  $\mu$ M, preferably of about 5 to 500  $\mu$ M, and most preferably of about 10 to 100  $\mu$ M.

Having now described the invention, it will be more readily understood through reference to the following examples that are provided by way of illustration and are not intended to be limiting the present invention.

Compounds of formula (I), have been found - in accordance with the present invention - to be PI3K inhibitors.

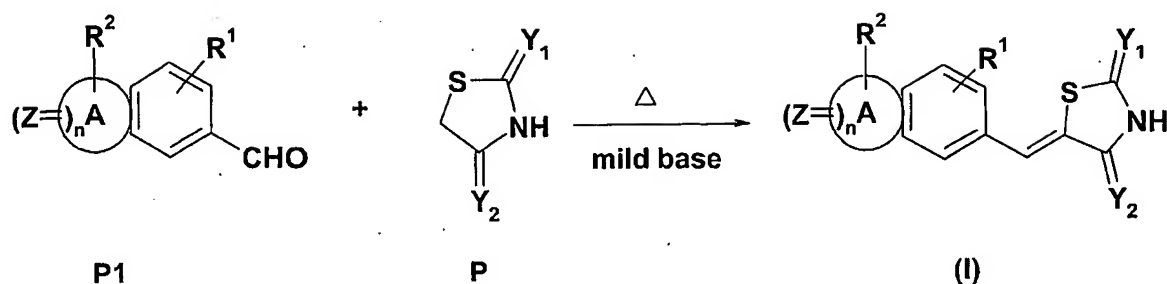
The azolidinone-vinyl fused-benzene derivatives according to formula (I) are either commercially available or - as is the case for compounds of any of formulae (I'), (Ia), (Ib), (Ic), (Id), (II), (III), (IV), (V) and (VI) - may be prepared from readily available starting materials using the below set out general methods and procedures.

It will be appreciated that where typical or preferred experimental conditions (i.e. reaction temperatures, time, moles of reagents, solvents etc.) are given, other experimental conditions can also be used unless otherwise stated. Optimum reaction conditions may vary with the particular reactants or solvents used, but such conditions can be determined by the person skilled in the art, using routine optimisation procedures.

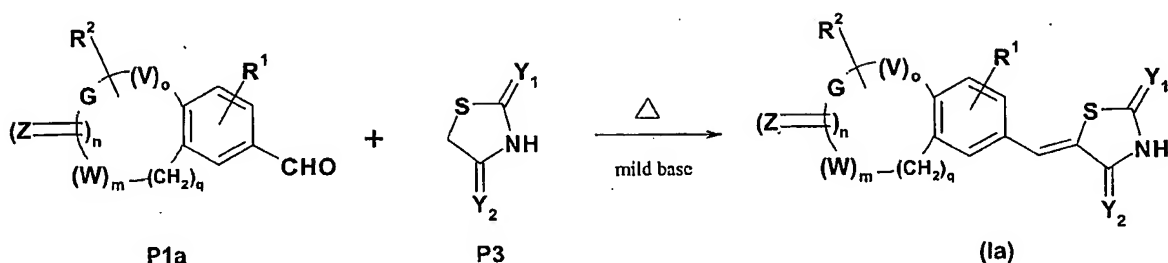
In the process illustrated in the following schemes  $R^1$ ,  $R^2$ ,  $R^4$ ,  $R^5$ , G, V, W,  $Y^1$ ,  $Y^2$ , Z, m, n, o, p and q are each as above-defined in the description.

Generally, the azolidinone-vinyl fused-benzene derivatives according to the general formula (I') could be obtained by several synthetic approaches, using both solution-phase  
5 and solid-phase chemistry protocols (Brummond et.al., *J.O.C.*, **64**, 1723-1726 (1999)), either by conventional methods or by microwave-assisted techniques.

Scheme 1



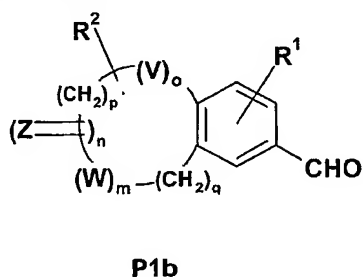
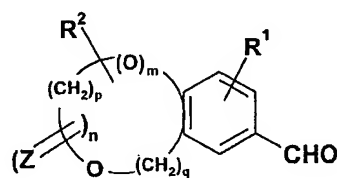
Scheme 2



5

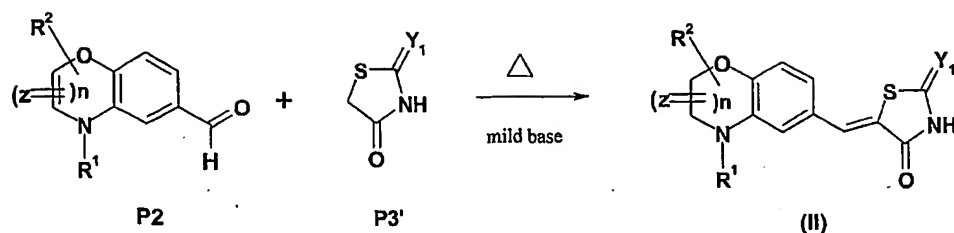
In a first step, approximately equimolar amounts of the aldehyde reactant **P1** (**P1a**) and compound **2** (in particular thiazolidinedione or rhodanin **P3**) are heated in the presence of a preferably mild base to provide the corresponding olefin of formula **(Ia)**. In the first step, **P1a** may be replaced by precursors **P1b** and **P1c** in order to obtain the final compounds **(Ib)** and **(Ic)** respectively as above described in the description.

10

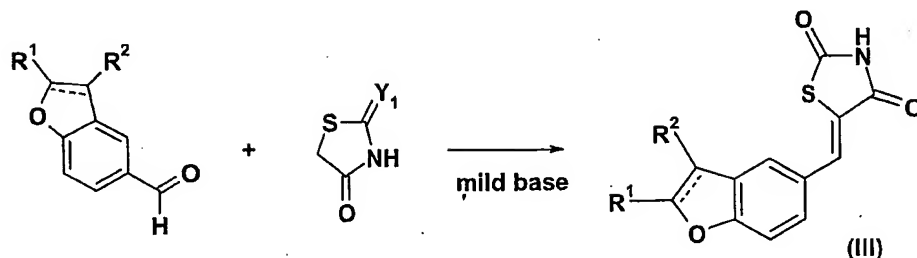
**P1b****P1c**

Particularly preferred process according to the invention are illustrated by the following schemes 3 and 4 in which compounds of formula **(II)** and **(III)** respectively, may be obtained using the same reaction as above-mentioned.

15 Scheme 3



Scheme 4



While this step may be carried out in the absence of a solvent at a temperature, which is sufficiently high to cause at least partial melting of the reaction mixture, it is preferably carried out in the presence of a inert solvent. A preferred temperature range is from about 100°C to 250°C, and especially preferred is a temperature of from about 120°C to 200°C. Examples of such solvents for the above reaction include solvents like dimethoxymethane, xylene, toluene, o-dichlorobenzene etc. Examples of suitable mild bases for the above reaction are alkali metal and alkaline earth salts of weak acids such as the (C<sub>1</sub>-C<sub>12</sub>)-alkyl carboxylic acids and benzoic acid, alkali metal and alkaline earth carbonates and bicarbonates such as calcium carbonate, magnesium carbonate, potassium bicarbonate and secondary amines such as piperidine, morpholine as well as tertiary amines such as pyridine, triethylamine, diisopropylethylamine, N-methylmorpholine, N-ethylpiperidine, N-methylpiperidine and the like. Especially preferred mild bases are sodium acetate or piperidine for reasons of economy and efficiency.

In a typical such reaction (Tietze et.al., in "The Knoevenagel reaction", p.341 ff., Pergamon Press, Oxford 1991, Eds.: Trost B.M., Fleming I.) the aldehyde starting material P1a and the other starting compound (e.g. thiazolidinedione) P3 are combined in approximately equimolar amounts with 0.5 to one equivalent of piperidine in dimethoxymethane or similar solvent and heated between 120 and 200°C at which the reaction is substantially complete in from about 15 minutes to 3 hours. The desired olefin



of formula (Ia) is then isolated by filtration, in case it precipitated out of the reaction mixture upon cooling, or for example, by mixing with water and subsequent filtration, to obtain the crude product, which is purified, if desired, e.g. by crystallization or by standard chromatographic methods.

- 5 Alternatively compounds of formula (Ia) may be obtained typically by mixing equimolar amounts of thiazolidinedione P3 with aldehyde P1a and molar excess, preferably a 2-4 fold excess, of anhydrous sodium acetate and the mixture is heated at a temperature high enough to effect melting, at which temperature the reaction is mainly complete in from 5 to 60 minutes.
- 10 Preferably the above reaction is carried out in acidic media such as acetic acid in the presence of sodium acetate or beta-alanine.

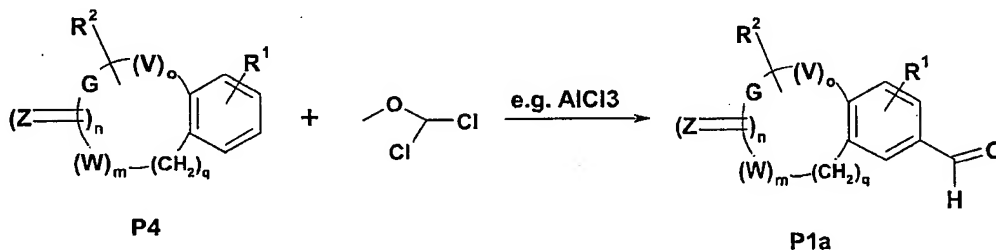
Above described reactions may be carried out alternatively under microwave conditions as heating source. Typically the aldehyde starting material P1a and thiazolidinedione P3 are combined in approximately equimolar amounts with 0.5 to one equivalent of piperidine in  
15 dimethoxymethane or similar solvent and heated between 140°C and 240°C at which the reaction is substantially complete in from 3 to 10 minutes.

The pharmaceutically acceptable cationic salts of compounds of the present invention are readily prepared by reacting the acid forms with an appropriate base, usually one equivalent, in a co-solvent. Typical bases are sodium hydroxide, sodium methoxide,  
20 sodium ethoxide, sodium hydride, potassium hydroxide, potassium methoxide, magnesium hydroxide, calcium hydroxide, benzathine, choline, diethanolamine, ethylenediamine, meglumine, benethamine, diethylamine, piperazine and tromethamine. The salt is isolated by concentration to dryness or by addition of a non-solvent. In some cases, salts can be prepared by mixing a solution of the acid with a solution of the cation (sodium  
25 ethylhexanoate, magnesium oleate), employing a solvent in which the desired cationic salt precipitates, or can be otherwise isolated by concentration and addition of a non-solvent.

2,4-Azolidinone derivatives P3 are commercially available from various sources.

The aldehydes of formula P1a are prepared by a variety of well known methods, for example starting from the corresponding carboxylic acid alkyl ester or carboxylic acid by oxido-reduction, using standard techniques to reduce carboxylic acid alkyl ester or carboxylic acid to benzylic alcohols with lithium aluminium hydride, diisopropylaluminum etc. and ultimately re-oxidize the corresponding benzylic alcohol to the corresponding aldehyde by mild oxidation with reagents such as manganese dioxide, chromic acid, Dess-Martin reagent or Swern oxidation, or under conditions known to produce aldehydes from primary alcohols. An alternative way may be the direct reduction of the corresponding carboxylic acid alkyl ester or carboxylic acid to the corresponding aldehyde, using DIBAL at low temperature or any other techniques known in the field.

Scheme 5



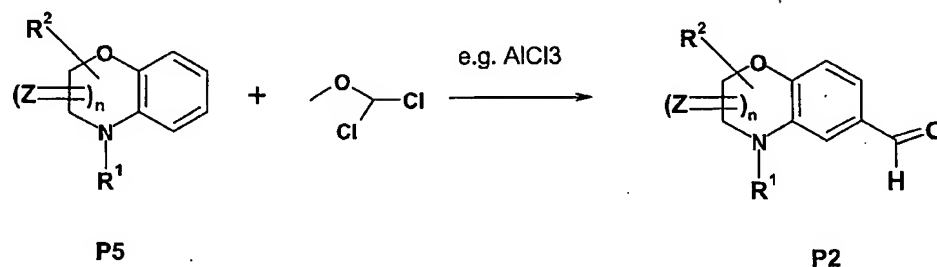
An alternative way to prepare the appropriate aldehydes is the selective reduction of a nitrile moiety to the corresponding aldehyde using known methods like e.g. DIBAL etc.

Another way to access aldehydes of formula P1a is the selective reduction of the corresponding acyl chloride using e.g. Lithiumaluminium-tri-tert-butoxyhydride (Cha J.S., Brown H.C., *J.O.C* 1993, **58**, p.4732-34). Another alternative way to produce the appropriate aldehydes is the reaction of the corresponding benzene derivative in a Friedl-Crafts type of reaction wherein the substrate P4 as shown in the above scheme 5 is reacted with 1,1-dichloromethyl methyl ether in the presence of a Lewis acid such as titanium tetrachloride or aluminium trichloride or any corresponding Lewis acids suitable for such type of reaction.

According to a more particularly preferred process of the invention, as described in the literature (Petrov O.I., Kalcheva V.B., Antonova A.T., *Collect. Czech. Chem. Commun*, **62**,

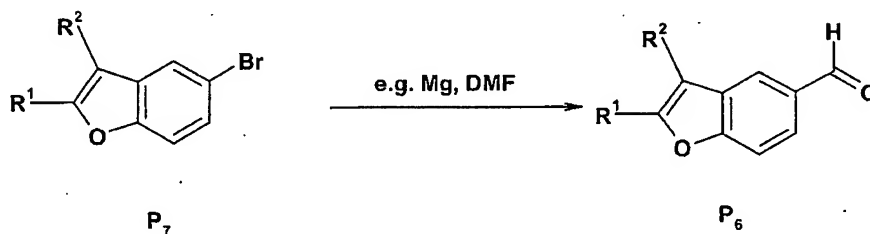
p.494-7 (1997)) and illustrated by Scheme 6 hereinafter, reactant P2 may be obtained starting from P5 by reacting with 1,1-dichloromethylmethyl ether as above-described.

Scheme 6



- 5 According to another more particularly preferred process of the invention, as illustrated by Scheme 7 hereinafter, reactant P6 may be obtained starting from P7 by reacting with DMF and the presence of magnesium or *n*-butyl-lithium or any other method known to the person skilled in the art.

Scheme 7

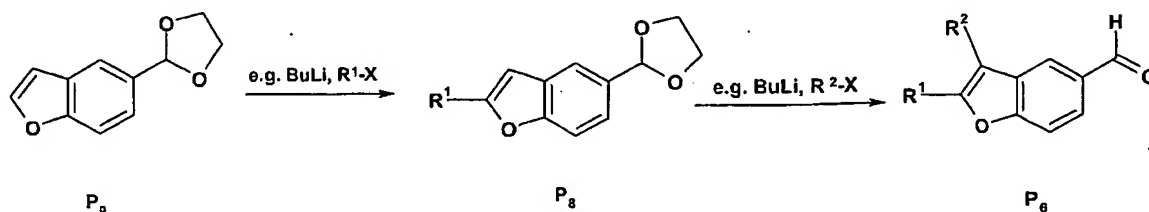


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According to another more particularly preferred process of the invention, as illustrated by Scheme 8 hereinafter, reactant P6 may be obtained starting from P9 by reacting *n*-butyllithium or LDA in the presence of an appropriate electrophile R<sup>1</sup>-X, or any other method known to the person skilled in the art. This method may be repeated for P8 in order to obtain P6 accordingly.

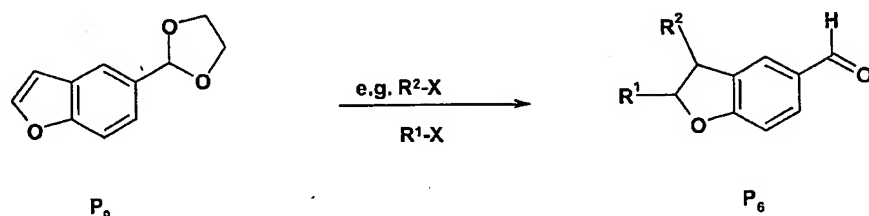
15

Scheme 8



Similarly, saturated precursors P6 may be obtained in a one-pot reaction using P9 and appropriate electrophiles  $R^1-X$  and  $R^2-X$  as set out in Scheme 9.

Scheme 9



- 5 If the above set out general synthetic methods are not applicable to obtain compounds according to formula (I) and/or to necessary intermediates for the synthesis of compounds of formula (I), suitable methods of preparation known by a person skilled in the art should be used. In general, the synthesis pathways for any individual compound of formula (I) will depend on the specific substituents of each molecule and upon the ready availability  
10 of intermediates necessary; again such factors being appreciated by those of ordinary skill in the art.

For all the protection and deprotection methods, see Philip J. Kocienski, in "*Protecting Groups*", Georg Thieme Verlag Stuttgart, New York, 1994 and, Theodora W. Greene and Peter G. M. Wuts in "*Protective Groups in Organic Synthesis*", Wiley Interscience, 3<sup>rd</sup>  
15 Edition 1999.

Compounds of this invention can be isolated in association with solvent molecules by crystallization from evaporation of an appropriate solvent. The pharmaceutically acceptable acid addition salts of the compounds of formula (I) which contain a basic center, may be prepared in a conventional manner. For example, a solution of the free base may be treated  
20 with a suitable acid, either neat or in a suitable solution, and the resulting salt isolated either by filtration or by evaporation under vacuum of the reaction solvent. Pharmaceutically acceptable base addition salts may be obtained in an analogous manner by treating a solution of compound of formula (I) with a suitable base. Both types of salts may be formed or interconverted using ion-exchange resin techniques.

When employed as pharmaceuticals, azolidinedione-vinyl fused-benzene derivatives of the present invention are typically administered in the form of a pharmaceutical composition. Hence, pharmaceutical compositions comprising a compound of formula (I) and a pharmaceutically acceptable carrier, diluent or excipient therefore are also within the scope  
5 of the present invention. A person skilled in the art is aware of a whole variety of such carrier, diluent or excipient compounds suitable to formulate a pharmaceutical composition.

The compounds of the invention, together with a conventionally employed adjuvant, carrier, diluent or excipient may be placed into the form of pharmaceutical compositions and  
10 unit dosages thereof, and in such form may be employed as solids, such as tablets or filled capsules, or liquids such as solutions, suspensions, emulsions, elixirs, or capsules filled with the same, all for oral use, or in the form of sterile injectable solutions for parenteral (including subcutaneous use). Such pharmaceutical compositions and unit dosage forms thereof may comprise ingredients in conventional proportions, with or without additional  
15 active compounds or principles, and such unit dosage forms may contain any suitable effective amount of the active ingredient commensurate with the intended daily dosage range to be employed.

Pharmaceutical compositions containing azolidinedione-vinyl fused-benzene derivatives of this invention can be prepared in a manner well known in the pharmaceutical art and  
20 comprise at least one active compound. Generally, the compounds of this invention are administered in a pharmaceutically effective amount. The amount of the compound actually administered will typically be determined by a physician, in the light of the relevant circumstances, including the condition to be treated, the chosen route of administration, the actual compound administered, the age, weight, and response of the  
25 individual patient, the severity of the patient's symptoms, and the like.

The pharmaceutical compositions of the present invention can be administered by a variety of routes including oral, rectal, transdermal, subcutaneous, intravenous, intramuscular and intranasal. The compositions for oral administration can take the form of bulk liquid

solutions or suspensions, or bulk powders. More commonly, however, the compositions are presented in unit dosage forms to facilitate accurate dosing. The term "unit dosage forms" refers to physically discrete units suitable as unitary dosages for human subjects and other mammals, each unit containing a predetermined quantity of active material  
5 calculated to produce the desired therapeutic effect, in association with a suitable pharmaceutical excipient. Typical unit dosage forms include prefilled, premeasured ampoules or syringes of the liquid compositions or pills, tablets, capsules or the like in the case of solid compositions. In such compositions, the thiazolidinedione-vinyl fused-benzene derivative is usually a minor component (from about 0.1 to about 50% by weight  
10 or preferably from about 1 to about 40% by weight) with the remainder being various vehicles or carriers and processing aids helpful for forming the desired dosing form.

Liquid forms suitable for oral administration may include a suitable aqueous or nonaqueous vehicle with buffers, suspending and dispensing agents, colorants, flavors and the like. Solid forms may include, for example, any of the following ingredients, or  
15 compounds of a similar nature: a binder such as microcrystalline cellulose, gum tragacanth or gelatine; an excipient such as starch or lactose, a disintegrating agent such as alginic acid, Primogel, or corn starch; a lubricant such as magnesium stearate; a glidant such as colloidal silicon dioxide; a sweetening agent such as sucrose or saccharin; or a flavoring agent such as pepper-mint, methyl salicylate, or orange flavoring.

20 Injectable compositions are typically based upon injectable sterile saline or phosphate-buffered saline or other injectable carriers known in the art. As above mentioned, the thiazolidinedione-vinyl fused-benzene derivatives of formula (I) in such compositions is typically a minor component, frequently ranging between 0.05 to 10% by weight with the remainder being the injectable carrier and the like.

25 The above described components for orally administered or injectable compositions are merely representative. Further materials as well as processing techniques and the like are set out in Part 5 of *Remington's Pharmaceutical Sciences*, 20<sup>th</sup> Edition, 2000, Marck Publishing Company, Easton, Pennsylvania, which is incorporated herein by reference.

The compounds of this invention can also be administered in sustained release forms or from sustained release drug delivery systems. A description of representative sustained release materials can also be found in the incorporated materials in *Remington's Pharmaceutical Sciences*.

5 In the following the present invention shall be illustrated by means of some examples which are not construed to be viewed as limiting the scope of the invention. The following abbreviations are hereinafter used in the accompanying examples: min (minute), hr (hour), g (gram), mmol (millimole), m.p. (melting point), eq (equivalents), ml (milliliter),  $\mu$ l (microliters), ACN (acetonitrile), Boc (butoxycarbonyl), Cbz (carboxybenzyl),  $\text{CDCl}_3$  (deuterated chloroform), cHex (cyclohexanes), dba (dibenzylidene acetone), DCM (dichloromethane), DEAD (diethylazodicarboxylate), DIC (diisopropyl carbodiimide), DIEA (diisopropyl ethylamine), DMAP (4-dimethylaminopyridine), DME (Dimethoxyethane), DMF (dimethylformamide), DMSO (dimethylsulfoxide),  $\text{DMSO-}d_6$  (deuterated dimethylsulfoxide), EDC (1-(3-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride), EtOAc (ethyl acetate),  $\text{Et}_2\text{O}$  (diethyl ether), Fmoc (9-fluorenylmethoxycarbonyl), HOBt (1-hydroxybenzotriazole),  $\text{K}_2\text{CO}_3$  (potassium carbonate),  $\text{MgSO}_4$  (magnesium sulfate), MsCl (methylsulfonyl chloride), MTBE (*tert*-butyl methyl ether), NaH (sodium hydride),  $\text{NaHCO}_3$  (sodium bicarbonate), nBuLi (n-butyllithium), PCC (pyridinium chlorochromate), PetEther (petroleum ether), QCl (tetrabutylammonium chloride), rt (room temperature), TBTU (*O*-benzotriazolyl-*N,N,N',N'*-tetramethyluronium-tetrafluoroborate), TEA (triethyl amine), TFA (trifluoroacetic acid), THF (tetrahydrofuran), TMOF (trimethylorthoformate), TMAD (*N,N,N',N'*-tetramethylazodicarboxamide), TosCl (toluenesulfonyl chloride)

#### Example Name

- |   |  |
|---|--|
| 1 | 5-(1,3-benzodioxol-5-ylmethylene)-1,3-thiazolidine-2,4-dione             |
| 2 | 5-(1,3-benzodioxol-5-ylmethylene)-2-thioxo-1,3-thiazolidin-4-one         |
| 3 | 5-(2,3-dihydro-1,4-benzodioxin-6-ylmethylene)-1,3-thiazolidine-2,4-dione |
| 4 | 5-(2,3-dihydro-1-benzofuran-5-ylmethylene)-1,3-thiazolidine-2,4-dione    |

- 5 5-[(7-methoxy-1,3-benzodioxol-5-yl)methylene]-1,3-thiazolidine-2,4-dione
- 6 5-[(9,10-dioxo-9,10-dihydroanthracen-2-yl)methylene]-1,3-thiazolidine-2,4-dione
- 7 (5-[(2,2-difluoro-1,3-benzodioxol-5-yl)methylene]-1,3-thiazolidine-2,4-dione
- 8 (5Z)-5-(1,3-dihydro-2-benzofuran-5-ylmethylene)-1,3-thiazolidine-2,4-dione
- 9 5-(1-benzofuran-5-ylmethylene)-1,3-thiazolidine-2,4-dione
- 10 5-[(4-methyl-3-oxo-3,4-dihydro-2H-1,4-benzoxazin-6-yl)methylene]-1,3-thiazolidine-2,4-dione
- 11 5-(1,3-benzodioxol-5-ylmethylene)-2-imino-1,3-thiazolidin-4-one
- 12 5-Quinolin-6-ylmethylene-thiazolidine-2,4-dione
- 13 5-Quinolin-6-ylmethylene-2-thioxo-thiazolidin-4-one
- 14 2-Imino-5-quinolin-6-ylmethylene-thiazolidin-4-one
- 15 5-(3-Methyl-benzo[d]isoxazol-5-ylmethylene)-thiazolidine-2,4-dione
- 16 5-(4-Phenyl-quinazolin-6-ylmethylene)-thiazolidine-2,4-dione
- 17 5-(4-Dimethylamino-quinazolin-6-ylmethylene)-thiazolidine-2,4-dione
- 18 5-[(4-aminoquinazolin-6-yl)methylene]-1,3-thiazolidine-2,4-dione
- 19 5-[(4-piperidin-1-ylquinazolin-6-yl)methylene]-1,3-thiazolidine-2,4-dione
- 20 5-[(4-morpholin-4-ylquinazolin-6-yl)methylene]-1,3-thiazolidine-2,4-dione
- 21 5-{[4-(benzylamino)quinazolin-6-yl]methylene}-1,3-thiazolidine-2,4-dione
- 22 5-{[4-(diethylamino)quinazolin-6-yl]methylene}-1,3-thiazolidine-2,4-dione
- 23 5-({4-[(pyridin-2-ylmethyl)amino]quinazolin-6-yl}methylene)-1,3-thiazolidine-2,4-dione
- 24 5-({4-[(pyridin-3-ylmethyl)amino]quinazolin-6-yl}methylene)-1,3-thiazolidine-2,4-dione
- 25 ethyl 1-{6-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]quinazolin-4-yl}piperidine-3-carboxylate
- 26 ethyl 1-{6-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]quinazolin-4-yl}piperidine-4-carboxylate
- 27 tert-butyl 1-{6-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]quinazolin-4-yl}-L-prolinate



- 28 5-{{4-(4-methylpiperazin-1-yl)quinazolin-6-yl}methylene}-1,3-thiazolidine-2,4-dione
- 29 5-{{4-(4-pyrimidin-2-ylpiperazin-1-yl)quinazolin-6-yl}methylene}-1,3-thiazolidine-2,4-dione
- 30 5-({4-[4-(4-fluorophenyl)piperidin-1-yl]quinazolin-6-yl}methylene)-1,3-thiazolidine-2,4-dione
- 31 5-{{4-(4-benzylpiperidin-1-yl)quinazolin-6-yl}methylene}-1,3-thiazolidine-2,4-dione
- 32 5-({4-[4-(2-phenylethyl)piperidin-1-yl]quinazolin-6-yl}methylene)-1,3-thiazolidine-2,4-dione
- 33 5-{{4-(4-methylpiperidin-1-yl)quinazolin-6-yl}methylene}-1,3-thiazolidine-2,4-dione
- 34 5-{{4-(4-hydroxypiperidin-1-yl)quinazolin-6-yl}methylene}-1,3-thiazolidine-2,4-dione
- 35 1-[6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-quinazolin-4-yl]-piperidine-4-carboxylic acid
- 36 1-[6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-quinazolin-4-yl]-piperidine-3-carboxylic acid
- 37 1-[6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-quinazolin-4-yl]-pyrrolidine-2-carboxylic acid
- 38 5-(4-Methylamino-quinazolin-6-ylmethylene)-thiazolidine-2,4-dione
- 39 5-(4-Methoxy-quinazolin-6-ylmethylene)-thiazolidine-2,4-dione
- 40 2-Imino-5-(4-methylamino-quinazolin-6-ylmethylene)-thiazolidin-4-one
- 41 2-Imino-5-(4-piperidine-quinazolin-6-ylmethylene)-thiazolidin-4-one
- 42 2-Imino-5-(4-dimethylamino-quinazolin-6-ylmethylene)-thiazolidin-4-one
- 43 5-(2-Methyl-2H-benzotriazol-5-ylmethylene)-thiazolidine-2,4-dione
- 44 5-(3-Methyl-3H-benzotriazol-5-ylmethylene)-thiazolidine-2,4-dione
- 45 5-(3-Ethyl-3H-benzoimidazol-5-ylmethylene)-thiazolidine-2,4-dione
- 46 5-{{[1-(4-phenylbutyl)-1H-benzimidazol-6-yl]methylene}-1,3-thiazolidine-2,4-dione
- 47 5-[(1-prop-2-yn-1-yl-1H-benzimidazol-6-yl)methylene]-1,3-thiazolidine-2,4-dione
- 48 5-[(1-{2-[4-(trifluoromethyl)phenyl]ethyl}-1H-benzimidazol-6-yl)methylene]-1,3-thiazolidine-2,4-dione

- 49 5-({1-[2-(4-hydroxyphenyl)ethyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione
- 50 methyl 4-{6-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1H-benzimidazol-1-yl}cyclohexanecarboxylate
- 51 5-({1-[2-(5-methoxy-1H-indol-3-yl)ethyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione
- 52 5-({1-[(1-methyl-1H-pyrazol-4-yl)methyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione
- 53 5-({1-[2-(3,4-dimethoxyphenyl)ethyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione
- 54 5-({1-[2-(4-phenoxyphenyl)ethyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione
- 55 5-({1-[4-(trifluoromethyl)benzyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione
- 56 4-{6-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1H-benzimidazol-1-yl}cyclohexanecarboxylic acid
- 57 5-[(1-isobutyl-1H-benzimidazol-6-yl)methylene]-1,3-thiazolidine-2,4-dione
- 58 5-({1-[2-(1,3-benzodioxol-4-yl)ethyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione
- 59 5-({1-[2-(2-phenoxyphenyl)ethyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione
- 60 5-{[1-(3,3-diphenylpropyl)-1H-benzimidazol-6-yl]methylene}-1,3-thiazolidine-2,4-dione
- 61 5-{[1-(2-methoxybenzyl)-1H-benzimidazol-6-yl]methylene}-1,3-thiazolidine-2,4-dione
- 62 5-{[1-(3-furylmethyl)-1H-benzimidazol-6-yl]methylene}-1,3-thiazolidine-2,4-dione
- 63 5-[(1-propyl-1H-benzimidazol-6-yl)methylene]-1,3-thiazolidine-2,4-dione
- 64 5-Quinoxalin-6-ylmethylene-thiazolidine-2,4-dione
- 65 5-Quinoxalin-6-ylmethylene-2-thioxo-thiazolidin-4-one
- 66 2-Imino-5-quinoxalin-6-ylmethylene-thiazolidin-4-one
- 67 5-Benzothiazol-6-ylmethylene-thiazolidine-2,4-dione
- 68 5-(3-Methyl-benzofuran-5-ylmethylene)-thiazolidine-2,4-dione
- 69 5-(2-Bromo-3-methyl-benzofuran-5-ylmethylene)-thiazolidine-2,4-dione
- 70 5-(3-bromo-benzofuran-5-ylmethylene)-thiazolidine-2,4-dione

- 71 3-[5-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-benzofuran-3-yl]-acrylic acid ethyl ester
- 72 3-[5-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-benzofuran-3-yl]-acrylic acid
- 73 5-[3-(3-Oxo-3-piperidin-1-yl-propenyl)-benzofuran-5-ylmethylene]-thiazolidine-2,4-dione
- 74 Methyl 1-((3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}prop-2-enoyl)prolinate
- 75 Methyl 1-((3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}prop-2-enoyl)-D-prolinate
- 76 (5-({3-[(3-oxo-3-pyrrolidin-1-ylprop-1-en-1-yl)-1-benzofuran-5-yl]methylene)-1,3-thiazolidine-2,4-dione
- 77 5-({3-[3-morpholin-4-yl-3-oxoprop-1-en-1-yl]-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione
- 78 Methyl 1-(3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}prop-2-enoyl)-L-prolinate
- 79 N-cyclohexyl-3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}-N-methylacrylamide
- 80 3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}-N-ethyl-N-(2-hydroxyethyl)acrylamide
- 81 N-cyclobutyl-3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}acrylamide
- 82 5-({3-[3-azetidin-1-yl-3-oxoprop-1-en-1-yl]-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione
- 83 5-({3-[3-(1,3-dihydro-2H-isoindol-2-yl)-3-oxoprop-1-en-1-yl]-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione
- 84 5-({3-[3-azepan-1-yl-3-oxoprop-1-en-1-yl]-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione
- 85 3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}-N-piperidin-1-ylacrylamide
- 86 3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}-N-(pyridin-3-ylmethyl)acrylamide
- 87 N-cyclohexyl-3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}acrylamide
- 88 5-({3-[3-(4-methylpiperazin-1-yl)-3-oxoprop-1-en-1-yl]-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione
- 89 N-cycloheptyl-3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}acrylamide

- 90 5-({3-[3-(2,5-dihydro-1H-pyrrol-1-yl)-3-oxoprop-1-en-1-yl]-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione
- 91 N-cyclopentyl-3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}acrylamide
- 92 3-[5-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-benzofuran-3-yl]-propionic acid ethyl ester
- 93 3-[5-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-benzofuran-3-yl]-propionic acid
- 94 5-[3-(3-Oxo-3-piperidin-1-yl-propyl)-benzofuran-5-ylmethylene]-thiazolidine-2,4-dione
- 95 6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-2,3-dihydro-benzo[1,4]oxazine-4-carboxylic acid tert-butyl ester
- 96 5-(3,4-Dihydro-2H-benzo[1,4]oxazin-6-ylmethylene)-thiazolidine-2,4-dione
- 97 5-(4-Benzoyl-3,4-dihydro-2H-benzo[1,4]oxazin-6-ylmethylene)-thiazolidine-2,4-dione
- 98 5-(4-Acetyl-3,4-dihydro-2H-benzo[1,4]oxazin-6-ylmethylene)-thiazolidine-2,4-dione
- 99 6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-benzo[1,4]oxazine-4-carboxylic acid tert-butyl ester
- 100 [6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-3-oxo-2,3-dihydro-benzo[1,4]-oxazin-4-yl]-acetic acid methyl ester
- 101 N-Benzyl-2-[6-(2,4-dioxo-thiazolidin-5-ylidenemethyl)-3-oxo-2,3-dihydro-benzo[1,4]oxazin-4-yl]-acetamide
- 102 5-(4-Butyl-3-oxo-3,4-dihydro-2H-benzo[1,4]oxazin-6-ylmethylene)-thiazolidine-2,4-dione
- 103 5-(4-Benzyl-3-oxo-3,4-dihydro-2H-benzo[1,4]oxazin-6-ylmethylene)-thiazolidine-2,4-dione
- 104 5-(2-Chloro-benzofuran-5-ylmethylene)-thiazolidine-2,4-dione
- 105 5-(3-Amino-benzo[d]isoxazol-5-ylmethylene)-thiazolidine-2,4-dione
- 106 5-(3-Phenylethynyl-benzofuran-5-ylmethylene)-thiazolidine-2,4-dione
- 107 5-Benzo[1,2,5]thiadiazol-5-ylmethylene-thiazolidine-2,4-dione
- 108 5-Benzo[1,2,5]oxadiazol-5-ylmethylene-thiazolidine-2,4-dione

- 109 5-(2-Methyl-benzofuran-6-ylmethylene)-thiazolidine-2,4-dione
- 110 5-(2-Carboxymethyl-benzofuran-6-ylmethylene)-thiazolidine-2,4-dione
- 111 5-(3-Bromo-2-fluoro-2,3-dihydro-benzofuran-6-ylmethylene)-thiazolidine-2,4-dione
- 112 5-(2-Fluoro-benzofuran-6-ylmethylene)-thiazolidine-2,4-dione

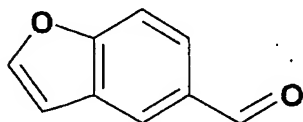
The following intermediate aldehydes are commercially available: 2,2-Difluoro-1,3-benzodioxole-5-carboxaldehyde, 1,3-Benzodioxole-5-carboxaldehyde, 1,4-Benzodioxan-6-carboxaldehyde, 9,10-Dioxo-9,10-dihydro-anthracene-2-carbaldehyde, 2,3-Dihydro-benzo[b]furan-5-carboxaldehyde, 3-Methoxy-4,5-methylenedioxybenzaldehyde.

- 5 Thiazolidinedione and Rhodanine are commercially available. Intermediate aldehydes were synthesized according to the protocols as mentioned below.

The HPLC, NMR and MS data provided in the examples described below were obtained as followed: HPLC: column Waters Symmetry C8 50 x 4.6 mm, Conditions: MeCN/H<sub>2</sub>O, 5 to 100% (8 min), max plot 230-400 nm; Mass spectra: PE-SCIEX API 150 EX (APCI and  
10 ESI), LC/MS spectra: Waters ZMD (ES); <sup>1</sup>H-NMR: Bruker DPX-300MHz.

The purifications were obtained as followed: Preparative HPLC Waters Prep LC 4000 System equipped with columns Prep Nova-Pak<sup>®</sup>HR C18 6 μm 60Å, 40x30mm (up to 100mg) or 40x300 mm (up to 1g). All the purifications were performed with a gradient of MeCN/H<sub>2</sub>O 0.09% TFA.

15 Intermediate 1: Preparation of 5-formyl-1-benzofuran



Step I Ethyl-2-formyl-4-bromophenoxy acetate:

- A mixture of 5-bromosalicylaldehyde (50g, 0.248mol), ethylbromoacetate (42g, 0.248mol)  
20 and K<sub>2</sub>CO<sub>3</sub> (68g, 0.49mol) in dry DMF (200mL) was stirred at RT for 12h. The reaction

mixture was filtered and filtrate diluted with water. The mixture was extracted with diethylether (4x200mL), washed with brine and concentrated to give crude ethyl-2-formyl-4-bromophenoxy acetate (64g, 90%) as a solid.

Step II: 4-Bromo-2-formylphenoxy acetic acid:

- 5 A mixture of ethyl-2-formyl-4-bromophenoxy acetate (60g, 0.209mol), LiOH (7.5g, 0.31mol), THF (250mL) and water (100mL) was stirred at RT for 24h. The reaction mixture was concentrated under reduce pressure and residue acidified with 1.5N HCl to pH=2. The solid precipitate obtained was filtered and dried to give 4-bromo-2-formylphenoxy acetic acid (50g, 94%).

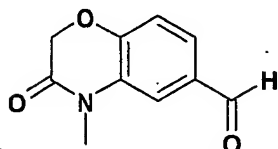
10 Step III: 5-Bromo-1-benzofuran:

- To a mixture of 2-formyl-4-bromophenoxy acetic acid (50g, 0.192mol), sodium acetate (100g, 1.21mol) in acetic acid (250mL) at 100°C was added acetic anhydride (100mL) portions during a period of 3h. The reaction mixture was then refluxed for 20h. The solvent was removed by distillation and residue diluted with 3N HCl (500mL) and refluxed for 2h.
- 15 The reaction mixture was then concentrated under vacuum and product extracted with pet. ether (3x200mL). The organic layer was washed with 10% NaHCO<sub>3</sub> solution and evaporated to give 5-bromo-1-benzofuran (15g, 40%) as a pale yellow liquid.

Step IV: 5-Formyl-1-benzofuran (P1a in scheme 2 for example 9):

- A mixture of 5-bromo-1-benzofuran (0.5g), Mg (0.92g, 0.038mol), I<sub>2</sub> (1 crystal) in dry
- 20 THF (2.5mL) under N<sub>2</sub> atmosphere was refluxed for 30min. To this was added a solution of 5-bromo-1-benzofuran (4.5g) in 25mL of dry THF) as soon as the I<sub>2</sub> color disappear and refluxed for another 2h. The reaction mixture was then cooled to -40°C and added dry DMF (3.6g) drop-wise and slowly warmed to RT for a period of 12h. The reaction mixture was then cooled to 0°C and acidified with 3N HCl to pH=2 and stirred for 30min.
- 25 The reaction mixture was then diluted with water (500mL), extracted with ethylacetate (2x200mL), washed with brine and dried. The solvent was removed under vacuum and purified by column chromatography over silica gel (pet. ether/CH<sub>2</sub>Cl<sub>2</sub>) to give 5-formyl-1-benzofuran (2g, 54%) as a liquid. LC-MS: M/Z ESI: 1.47 min, 147.34 (M+1).

Intermediate 2: Preparation of 4-Methyl-3-oxo-3,4-dihydro-2H-benzo[1,4]oxazine-6-carbaldehyde



5 Step I: 2-(N-methylamino)-phenol:

1g of benzoxazole was dissolved in 20 ml of THF. 0.9g of NaBH<sub>4</sub> were added under nitrogen and stirring. The suspension was cooled to 0°C and 0.86 ml of acetic acid dissolved in 5ml THF were slowly added, keeping the reaction temperature below 5°C. The reaction was stirred at 0°C for 30 minutes and for further 12 hours at room temperature. The reaction mixture was again cooled to 0°C and 50ml of sat. NH<sub>4</sub>Cl solution were added carefully. The phases were separated and the aqueous layer extracted twice with EtOAc. The combined organic layers were washed with brine, dried over MgSO<sub>4</sub> and filtered. Removal of the solvent afforded 0.97g (of pure 2-(N-methylamino)-phenol.

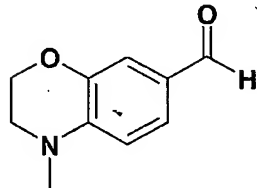
15 Step II: 4-Methyl-4H-benzo[1,4]oxazin-3-one

1g of 2-(N-methylamino)-phenol were dissolved in chloroform, followed by the addition of 10ml of sat. NaHCO<sub>3</sub> in water. To this suspension was added slowly under vigorous stirring a solution of 1g of 2-chloroacetylchloride in acetone. The reaction mixture was stirred for 2 hours at room temperature. The layers were separated. The organic layer was washed with water and dried over Na<sub>2</sub>SO<sub>4</sub>. After evaporating the solvent, the red oil was taken up in 30 ml DMF and 1g of K<sub>2</sub>CO<sub>3</sub> were added and the slurry was heated at 70°C for additional 2 hours. The cyclization was followed by TLC. 200 ml of EtOAc were added and the organic layer was washed 3x with 0.1N HCl and 5x with brine. The remaining organic layer was dried over MgSO<sub>4</sub> and filtrated. EtOAc was removed under reduced pressure affording 1.45g of pure 4-methyl-4H-benzo[1,4]oxazin-3-one.

25 Step III: 4-Methyl-3-oxo-3,4-dihydro-2H-benzo[1,4]oxazine-6-carbaldehyde

1g of  $\text{AlCl}_3$  were suspended in 10 ml DCM, 0.5 ml of nitromethane were added to dissolve  $\text{AlCl}_3$ , and the solution was cooled to  $0^\circ\text{C}$ . 4-Methyl-4H-benzo[1,4]oxazin-3-one (0.5g, 3.06 mmol) dissolved in DCM was added to the above solution and stirred for 15 minutes at  $0^\circ\text{C}$ . To this solution was further added 0.36ml of bis-chloromethyl-methylether in DCM. The reaction was stirred at  $0^\circ\text{C}$  for 15 minutes and at room temperature for 3h. The crude reaction mixture was then poured onto ice, the layers were separated and the organic phase was washed with  $\text{NaHCO}_3$  and brine. After drying over  $\text{MgSO}_4$  and filtration the solvent was evaporated, which afforded 0.43g of crude product. The dark oil was purified by flash chromatography using EtOAc and cyclohexane as eluents, affording 0.2g (37%) of 4-methyl-3-oxo-3,4-dihydro-2H-benzo[1,4]oxazine-6-carbaldehyde as colourless solid. HPLC: 2.07 min. LC-MS: M/Z ESI: 1.31 min, 192.28 (M+1).

Intermediate 3: Preparation of 4-methyl-3,4-dihydro-2H-benzo[1,4]oxazine-7-carbaldehyde



Step I : 4-Methyl-3,4-dihydro-2H-benzo[1,4]oxazine

0.97g of 2-(N-methylamino)-phenol were dissolved in 50ml acetone, followed by the addition of 2g of  $\text{K}_2\text{CO}_3$  dissolved in water. To this suspension was added slowly a solution of 2.66g of dibromoethane in acetone. The reaction mixture was stirred for 22 hours under reflux. Acetone was evaporated and 200ml of EtOAc were added and the organic layer was washed 3x with 0.1N HCl and 3x with brine. The remaining organic layer was dried over  $\text{MgSO}_4$  and filtrated. EtOAc was removed under reduced pressure affording 1g of pure 4-methyl-3,4-dihydro-2H-benzo[1,4]oxazine.

Step II 4-Methyl-3,4-dihydro-2H-benzo[1,4]oxazine-7-carbaldehyde

4-Methyl-3,4-dihydro-2H-benzo[1,4]oxazine dissolved in 200ul DMF under Argon.  $\text{POCl}_3$  was added under Argon. The reaction was heated and a closed vial at  $90^\circ\text{C}$  for 75min. 1ml of NaAc in water was added and stirred while a brown oil was formed. The oil was

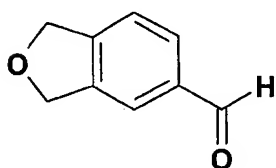


extracted with DCM. The organic layer was washed with brine, dried and evaporated to dryness, affording 0.18g (76%) of 4-methyl-3,4-dihydro-2H-benzo[1,4]oxazine-7-carbaldehyde as colourless solid.

LC-MS: M/Z ESI: 1.37 min, 178.35 (M+1).

5

#### Intermediate 4: Preparation of 1,3-Dihydroisobenzofuran-5-carbaldehyde



#### Step I (1,3-Dihydro-isobenzofuran-5-yl)-methanol

10 In a round bottom flask with reflux condenser were placed 1.0g of 3-Prop-2-ynyloxy-propyne and 2.08g of propargylic alcohol in 10ml ethanol, followed by the addition of 9.8mg of tris(triphenylphosphine)rhodium chloride (Wilkinson catalyst) at room temperature. The reaction was heated up to 70°C, while the reaction colour turned yellow rapidly. After 1 day stirring at r.t., TLC analysis showed complete conversion of the

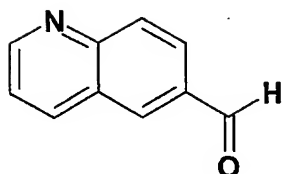
15 starting material. The solvent was evaporated, diluted with DCM and extracted with H<sub>2</sub>O, dried over MgSO<sub>4</sub>. The brown mixture was purified by flash chromatography using 8/2 cyclohexane / AcOEt as mobile phase affording (1,3-Dihydro-isobenzofuran-5-yl)-methanol as a colourless pure solid (0.92g, 60%).

#### Step II: 1,3-Dihydroisobenzofuran-5-carbaldehyde

20 (1,3-Dihydro-isobenzofuran-5-yl)-methanol (440mg, 2.9mmol) was dissolved in 20 ml of DCM. 1,1,1-Triacetoxy-1,1-dihydro-1,2-benziodoxol-3(1H)-one (Dess-Martin reagent) (1.3g, 3.2mmol) was added and the reaction was stirred at r.t. for 4h. The reaction mixture was diluted with ether and extracted 2x with NaOH 1N, 2x with H<sub>2</sub>O and dried over MgSO<sub>4</sub>. The crude product was sufficiently pure and used without any further purification.

25 HPLC: 2.00 min. LC-MS: M/Z ESI: 1.50 min, 149.18 (M+1).

#### Intermediate 5: Preparation of Quinoline-6-carbaldehyde



#### Step I: Quinolin-6-yl-methanol

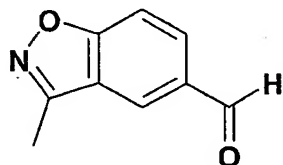
5g of methyl quinoline-6-carboxylate was dissolved in dry THF. Under Argon was added  
5 LiAlH<sub>4</sub> 1M in THF (2 eq.) at -20°C. The solution was stirred at that temperature for 1h.  
Isopropanol was slowly added and the crude filtered through celite and washed with DCM.  
Concentration gave 3.6 g (85%) of pure alcohol.  
HPLC: 1.10 min. LC-MS: M/Z ESI: 0.91 min, 160.43 (M+1).

#### Step II: Quinoline-6-carbaldehyde

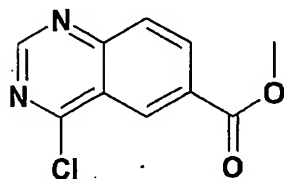
10 2g of quinolin-6-yl-methanol was dissolved in DCM. 15g of MnO<sub>2</sub> was added and the  
reaction mixture was stirred for 5h. The crude filtered through celite and washed  
extensively with DCM. Concentration gave 1.85g (93%) of pure aldehyde.  
HPLC: 0.8 min. LC-MS: M/Z ESI: 1.07 min, 158.37 (M+1). <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 10.19  
(s, 1H), 9.06 (t, J=3Hz, 1H), 8.6-8.66 (m, 2H), 8.15 (s, 2H), 7.68 (dd, J=3Hz, 9Hz, 1H).

15 The following intermediate was synthesized accordingly using the suitable starting  
materials :

#### Intermediate 6: Preparation of 3-Methyl-benzo[d]isoxazole-5-carbaldehyde



20 HPLC: 2.06 min. LC-MS: M/Z ESI: 1.26 min, 162.31 (M+1). <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ  
10.10 (s, 1H), 8.52 (s, 1H), 8.16 (d, J=12Hz, 1H), 8.15 (s, 2H), 7.90 (d, J=9Hz, 1H), 2.63  
(s, 3H).

Intermediate 7: Preparation of 4-Chloro-quinazoline-6-carboxylic acid methyl esterStep I: 4-Nitro isophthalic acid

- 5 A mixture of 3-methyl-4-nitrobenzoic acid (150g, 0.825mol), pyridine (1.5L) and water (1.5L) was heated to reflux. To the hot reaction mixture was added  $\text{KMnO}_4$  (10mol) portion wise and reflux for 72h. The hot reaction mixture was filtered through celite and washed with hot water. The filtrate was concentrated under vacuum, residue diluted with water (750mL) and acidified with con. HCl at  $0^\circ\text{C}$ . The solid obtained was filtered, washed  
10 with water and dried under vacuum to give 4-nitro isophthalic acid (98g, 56%).  
TLC, Chloroform/Methanol, 7:3,  $R_f=0.2$

Step II: 4-Amino isophthalic acid

- To a solution of 4-nitro isophthalic acid (98g, 0.457mol) in methanol (5L) was added Pd/C  
15 (20%) and hydrogenated at RT for 4h. The reaction mixture was filtered through celite and filtrate concentrated under vacuum to give 4-amino isophthalic acid (72g, 87%) as a solid.  
TLC, Chloroform/Methanol, 7:3,  $R_f=0.4$

Step III: 4-Oxo-3,4-dihydroquinazoline-6-carboxylic acid

- 20 A mixture of 4-amino isophthalic acid (17g, 0.093mol) and formamide (85mL) was heated at  $180^\circ\text{C}$  for 5h. The reaction mixture was cooled to RT and added acetone. The solid precipitate thus obtained was stirred for 2h, filtered and dried to give 4-oxo-3,4-dihydroquinazoline-6-carboxylic acid (11g, 61%).  
TLC, Chloroform/Methanol, 8:2,  $R_f=0.25$

25

Step IV: 4-Oxo-3,4-dihydroquinazoline-6-methyl carboxylate

To a solution of 4-oxo-3,4-dihydroquinazoline-6-carboxylic acid (24g, 0.126mol) in dry methanol (800mL) was added thionylchloride (37g) at  $5^\circ\text{C}$  and then refluxed at  $80^\circ\text{C}$  for

5h. The reaction mixture was concentrated under vacuum and crude taken in ethylacetate (250mL). The organic layer was washed with 10% aqueous NaHCO<sub>3</sub>, water, brine and dried. The solvent was removed under vacuum to give 4-oxo-3,4-dihydroquinazoline-6-methyl carboxylate (24g, 92%) as a solid.

5 TLC, Chloroform/Methanol, 8:2, R<sub>f</sub>=0.6

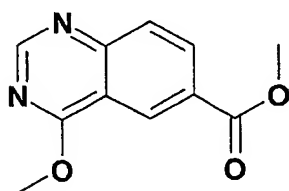
#### Step V: Methyl-4-chloroquinazoline-6-carboxylate

10 A mixture of 4-oxo-3,4-dihydroquinolin-6-methyl carboxylate (12g, 0.058mol) and phosphorylchloride (180mL) was heated to reflux for 7h. Excess phosphorylchloride was distilled off and crude taken in ethyl acetate (250mL). The organic layer was washed with 10% aqueous NaHCO<sub>3</sub> solution, water, brine and dried. The solvent was removed under vacuum and crude purified by column chromatography over silica gel (30% ethylacetate in pet. ether) to give methyl-4-chloroquinazoline-6-carboxylate (4.5g, 34%) as a solid.

TLC, pet. ether/EtOAc, 1:1, R<sub>f</sub>=0.65

15 LC-MS: M/Z ESI: 1.50 min, 223.19 (M+1). <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 8.66 (d, J=1.9Hz, 1H), 8.39 (s, 1H), 8.30 (dd, J=0.6Hz, 8.5Hz, 1H), 7.79 (d, J=8.5Hz, 1H), 3.90 (s, 3H).

#### Intermediate 8: Preparation of 4-Methoxy-quinazoline-6-carboxylic acid methyl ester



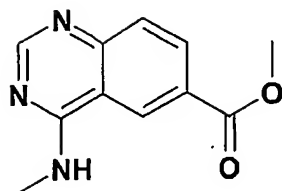
20 200 mg of methyl-4-chloroquinoline-6-carboxylate were stirred in 5 ml MeOH in the presence of 1eq. of DIEA at 60°C for 24h. MeOH was evaporated and the crude residue was taken up in EtOAc and washed with NH<sub>4</sub>Cl affording a white solid sufficiently pure for the next step.

HPLC: 2.3 min. LC-MS: M/Z ESI: 1.19 min, 219.17 (M+1).

25

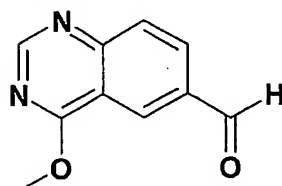
The following intermediate was synthesized according to the synthesis of intermediate 8:

#### Intermediate 9: Preparation of 4-Methylamino-quinazoline-6-carboxylic acid methyl ester



HPLC: 1.12 min. LC-MS: M/Z ESI: 1.06 min, 218.31 (M+1).

Intermediate 10: Preparation of 4-Methoxy-quinazoline-6-carbaldehyde

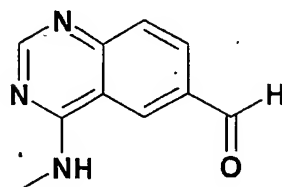


5

This intermediate was prepared according to the synthesis of intermediate 5 starting from 4-Methoxy-quinazoline-6-carboxylic acid methyl ester.

HPLC: 1.41 min. LC-MS: M/Z ESI: 1.24 min, 189.31 (M+1).

Intermediate 11: Preparation of 4-Methylamino-quinazoline-6-carbaldehyde

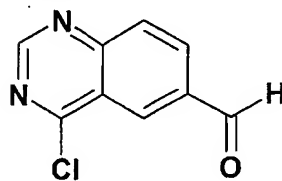


10

This intermediate was prepared according to the synthesis of intermediate 5 starting from 4-Methylamino-quinazoline-6-carboxylic acid methyl ester.

HPLC: 1.3 min. LC-MS: M/Z ESI: 0.90 min, 188.34 (M+1).

Intermediate 12: Preparation of 4-Chloro-quinazoline-6-carbaldehyde



15

Step I: 4-Chloroquinazoline-6-yl methanol

To a solution of methyl-4-chloroquinazoline-6-carboxylate (3.5g, 0.015mol) in dry THF (35mL) at  $-25^{\circ}\text{C}$  was added DIBAL-H (4.4g, 0.031mol) and stirred at  $-25^{\circ}\text{C}$  to RT for 2h. The reaction mixture was cooled to  $-10^{\circ}\text{C}$  and quenched with 10% aqueous  $\text{NaHCO}_3$  (9mL). The reaction mixture was extracted with ethylacetate (100mL), washed with water, brine and dried. The solvent was removed under vacuum to give 4-chloroquinoline-6-yl methanol (2g, 66%).

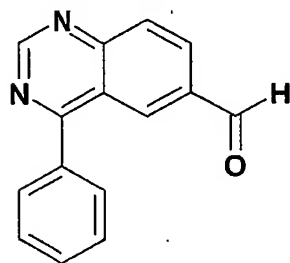
TLC, Chloroform/Methanol, 8:2,  $R_f=0.35$

Step II : 4-Chloroquinazoline-6-carboxaldehyde

To a solution of 4-chloroquinazoline-6-yl-methanol (3.5g, 0.018mol) in dry  $\text{CH}_2\text{Cl}_2$  (100mL) was added Dess-Martin periodinane (8.4g, 0.019mol) and stirred at RT for 30min. The reaction mixture was washed with 10% aqueous  $\text{NaHCO}_3$  (75mL), water, brine and dried. The solvent was removed under vacuum to give 4-chloroquinazoline-6-carboxaldehyde (3g, 88%) as pale yellow solid.

TLC, Chloroform/Methanol, 9:1,  $R_f=0.6$

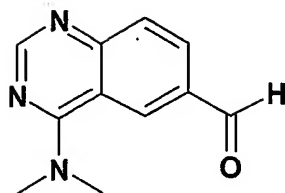
Intermediate 13: Preparation of 4-Phenyl-quinazoline-6-carbaldehyde



4-Chloro-quinazoline-6-carbaldehyde (50mg, 0.26mmol),  $\text{Pd}(\text{PPh}_3)_4$  (13mg, 0.01mmol), phenylboronic acid (63mg, 0.52mmol) and sodium carbonate (sat. sol: 50ul) were heated up in toluene at  $100^{\circ}\text{C}$  for 12h. After evaporation of the solvents, the residue was taken up in ethyl acetate and washed with brine twice. Organic phases were then concentrated and raw material was purified on silica gel using DCM/EtOH 95:5 as eluents to give 50 mgs (82%) of the desired cpd with a 85% purity.

HPLC: 2.68 min. LC-MS: M/Z ESI: 1.25 min, 235.30 (M+1).

Intermediate 14: Preparation of 4-Dimethylamino-quinazoline-6-carbaldehyde



4-Chloro-quinazoline-6-carbaldehyde (200mg, 1mmol) was dissolved in 10ml dioxane. To this solution was added a solution of dimethylamine in water (5eq.). The mixture was stirred during 2h at r.t. Evaporation of the solvents and remaining amine under high vacuum afforded pure 4-Dimethylamino-quinazoline-6-carbaldehyde as a yellow solid, which was used for the next step without further purification (190mg = 91%).

HPLC: 0.91 min. LC-MS: M/Z ESI: 1.23 min, 202.33 (M+1).  $^1\text{H}$  NMR ( $\text{CDCl}_3$ ):  $\delta$  10.19 (s, 1H), 8.70 (s, 1H), 8.50 (d,  $J=3\text{Hz}$ , 1H), 8.15 (dd,  $J=3\text{Hz}$ , 9Hz, 1H), 7.88 (d,  $J=9\text{Hz}$ , 1H).

The following intermediates were synthesized in a similar way using the suitable amines as nucleophiles.

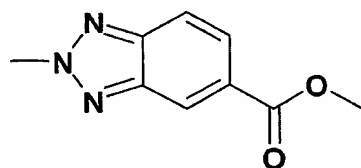
N°	Intermediate	M/Z ESI:(M+1).
15	4-Piperidin-1-yl-quinazoline-6-carbaldehyde	242.27
16	4-Amino-quinazoline-6-carbaldehyde	174.18
17	4-Benzylamino-quinazoline-6-carbaldehyde	264.30
18	4-[(Pyridin-2-ylmethyl)-amino]-quinazoline-6-carbaldehyde	265.33
19	4-[(Pyridin-3-ylmethyl)-amino]-quinazoline-6-carbaldehyde	265.33
20	4-(4-Methyl-piperazin-1-yl)-quinazoline-6-carbaldehyde	257.31
21	4-Diethylamino-quinazoline-6-carbaldehyde	230.28
22	4-Morpholin-4-yl-quinazoline-6-carbaldehyde	244.26
23	1-(6-Formyl-quinazolin-4-yl)-piperidine-3-carboxylic acid ethyl ester	314.36
24	1-(6-Formyl-quinazolin-4-yl)-pyrrolidine-2-carboxylic acid tert-butylester	328.39

25	1-(6-Formyl-quinazolin-4-yl)-piperidine-4-carboxylic acid ethyl ester	314.36
26	4-(4-Hydroxy-piperidin-1-yl)-quinazoline-6-carbaldehyde	258.30
27	4-(4-Methyl-piperidin-1-yl)-quinazoline-6-carbaldehyde	256.32
28	4-(4-Phenethyl-piperidin-1-yl)-quinazoline-6-carbaldehyde	346.42
29	4-(4-Benzyl-piperidin-1-yl)-quinazoline-6-carbaldehyde	332.40
30	4-[4-(4-Fluoro-phenyl)-piperidin-1-yl]-quinazoline-6-carbaldehyde	336.38
31	4-(4-Pyrimidin-2-yl-piperazin-1-yl)-quinazoline-6-carbaldehyde	321.36

#### Intermediates 32: Preparation of Methyl-benzotriazole-5-carboxylic acid methyl ester

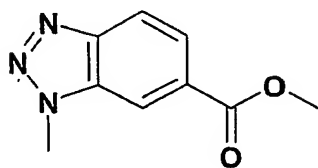
1 g of Benzotriazole-5-carboxylic acid methyl ester (5.64mmol) was dissolved in 20ml DMF at 0°C. To this solution was added 1eq. of NaH (60%) at 0°C. The mixture was stirred for 30min at 0°C, 801 mg (1eq.) of Methyl iodide were slowly added, and the resulting reaction mixture was stirred for 2h at rt. EtOAc was added and the organic layer was washed extensively with brine and water, dried over MgSO<sub>4</sub> and filtered to afford 1g of crude Methyl-benzotriazole-5-carboxylic acid methyl ester as three different regio-isomers. The separation was performed on silica gel using EtOAc/CH<sub>3</sub> 3:7 as eluents.

#### Intermediate 32a: 2-Methyl-2H-benzotriazole-5-carboxylic acid methyl ester



2-Methyl-2H-benzotriazole-5-carboxylic acid methyl ester eluted as first fraction (250mg, 22%). HPLC: 2.32 min. <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 8.56 (s, 1H), 8.02 (d, J=9Hz, 1H), 7.93 (d, J=9Hz, 1H), 4.55 (s, 3H), 3.90 (s, 1H).

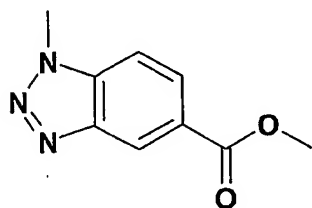
#### Intermediate 32b: 3-Methyl-3H-benzotriazole-5-carboxylic acid methyl ester





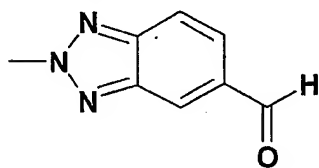
3-Methyl-3H-benzotriazole-5-carboxylic acid methyl ester eluted as 2<sup>nd</sup> fraction (130mg , 12%). HPLC: 2.03 min. <sup>1</sup>H NMR (DMSO-d<sub>6</sub>)  $\delta$  8.56 (s, 1H), 8.13 (d,  $J=6$ Hz, 1H), 7.93 (d,  $J=9$ Hz, 1H), 4.39 (s, 3H), 3.92 (s, 3H).

5 Intermediate 32c: 1-Methyl-1H-benzotriazole-5-carboxylic acid methyl ester



1-Methyl-1H-benzotriazole-5-carboxylic acid methyl ester eluted as 3<sup>rd</sup> fraction (135mg , 12%). HPLC: 2.03 min. <sup>1</sup>H NMR (DMSO-d<sub>6</sub>)  $\delta$  8.62 (s, 1H), 8.11 (d,  $J=9$ Hz, 1H), 7.97(d, 9Hz, 1H), 4.35 (s, 3H), 3.90 (s, 3H).

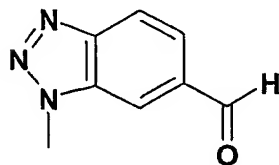
10 Intermediate 33: 2-Methyl-2H-benzotriazole-5-carbaldehyde



This intermediate has been synthesized according to the synthesis of intermediate 5 using 2-Methyl-2H-benzotriazole-5-carboxylic acid methyl (intermediate 32a) ester as starting point.

15 HPLC: 1.88 min. <sup>1</sup>H NMR (DMSO-d<sub>6</sub>)  $\delta$  10.12 (s, 1H), 8.65 (s, 1H), 8.06 (d,  $J=9$ Hz, 1H), 7.85 (d,  $J=9$ Hz, 1H), 4.57 (s, 3H).

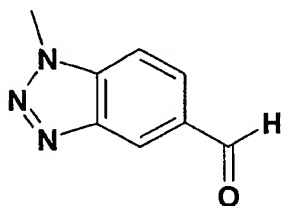
Intermediate 34: 3-Methyl-3H-benzotriazole-5-carbaldehyde



This intermediate has been synthesized according to the synthesis of intermediate 5 using 3-Methyl-3H-benzotriazole-5-carboxylic acid methyl ester (intermediate 32b) as starting point.

HPLC: 1.49 min.  $^1\text{H}$  NMR (DMSO- $d_6$ )  $\delta$  10.18 (s, 1H), 8.54 (s, 1H), 8.20 (d,  $J=9\text{Hz}$ , 1H),  
5 7.88(d,  $J=9\text{Hz}$ , 1H), 4.41 (s, 3H).

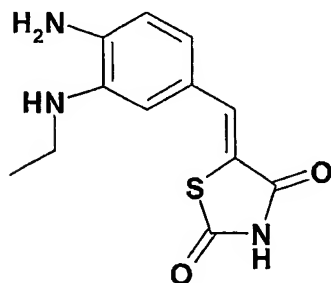
Intermediate 35: 1-Methyl-1H-benzotriazole-5-carbaldehyde



This intermediate has been synthesized according to the synthesis of intermediate 5 using 1-Methyl-1H-benzotriazole-5-carboxylic acid methyl ester as starting point (intermediate  
10 32c).

HPLC: 1.49 min. LC-MS: M/Z ESI: 1.07 min, 162.32 (M+1).  $^1\text{H}$  NMR (DMSO- $d_6$ )  $\delta$   
10.13 (s, 1H), 8.70 (s, 1H), 8.05 (s, 2H), 4.36 (s, 3H).

Intermediate 36: 5-(4-Amino-3-ethylamino-benzylidene)-thiazolidine-2,4-dione



Step I : 3-Fluoro 4-nitro benzyl alcohol (Bioorg. Med. Chem. 7, 1999, 2647)

To an ice-cooled suspension of  $\text{NaBH}_4$  (204mg, 5.4mmol, 2eq.) in THF (10mL) was added dropwise 3-fluoro 4-nitro benzoic acid (500mg, 2.7mmol, 1eq.) in THF (10mL) over 30  
20 minutes.  $\text{BF}_3\text{-Et}_2\text{O}$  (7.3mmol, 2.7eq.) was then added dropwise over 30 minutes. The solution was stirred at room temperature over night. 1N HCl was added dropwise to quench  $\text{NaBH}_4$  excess. The solvent was removed *in vacuo*, the residue dissolved in DCM,

washed with water, brine. The organic layer was then dried over  $\text{MgSO}_4$  and the solvent removed *in vacuo* to give 425 mg of 3-fluoro 4-nitro benzyl alcohol (92% yield). The compound was used in the following step with no further purification.

$^1\text{H}$  NMR:  $\delta$ =(400 MHz,  $\text{CDCl}_3$ ): 7.97 (m, 1H), 7.28 (m, 1H), 7.18 (m, 1H), 4.75 (m, 2H).

5.

Step II: 3-Fluoro 4-nitro benzyl aldehyde

3-fluoro 4-nitro benzyl alcohol (116mg, 0.68mmol, 1eq.) was dissolved in DCM (10ml) and treated with  $\text{MnO}_2$  (580mg, 6.73mmol, 10eq.) and the suspension stirred at room temperature over night.  $\text{MnO}_2$  was filtered off the suspension using celite and the solvent

10 evaporated to give the corresponding aldehyde as a white solid (66% yield).

$^1\text{H}$  NMR:  $\delta$ =(400 MHz,  $\text{CDCl}_3$ ): 9.98 (s, 1H, CHO), 8.08 (m, 1H, ArH), 7.78 (m, 2H, ArH).

Step III: 5-(3-Fluoro-4-nitro-benzylidene)-thiazolidine-2,4-dione (J. Med. Chem. 37, 2, 1994, 322)

15

A mixture of 3-fluoro 4-nitro benzyl aldehyde (280mg, 1.65mmol, 1eq.), thiazolidine-dione (193mg, 1.65mmol, 1eq.) and  $\beta$ -alanine (95mg, 1.1mmol, 0.65eq.) in acetic acid (5mL) was stirred over night at 100°C. The cooled reaction mixture was added to water and stirred for 1 hour. The precipitated product was filtered and washed with water and

20 dried to yield the final product as a yellow/orange solid (77% yield).

$^1\text{H}$  NMR:  $\delta$ =(400 MHz,  $(\text{CD}_3)_2\text{CO}$ ): 8.0 (m, 1H, ArH), 7.68 (m, 2H, ArH), 7.53 (s, 1H, CH=C).

Step IV: 5-(3-Ethylamino-4-nitro-benzylidene)-thiazolidine-2,4-dione

25 5-(3-Fluoro-4-nitro-benzylidene)-thiazolidine-2,4-dione (200mg, 0.75mmol, 1eq.), was dissolved in DME (6mL) and TEA (208 $\mu\text{L}$ , 1.5mmol, 2eq.) and a solution of ethylamine (2eq.) was added. The reaction mixture was shaken at 60°C over night. The solvent was removed *in vacuo* and residue dissolved in ethyl acetate and washed with 10% ammonium chloride aqueous solution. The organic layer was dried on  $\text{Na}_2\text{SO}_4$  and the solvent

evaporated to give the corresponding aniline derivative as either red oil, which was used for the next step without further purification.

Step V: 5-(3-Ethylamino-4-amino-benzylidene)-thiazolidine-2,4-dione

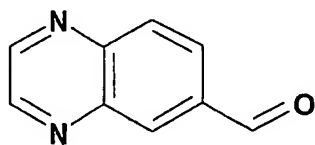
- 5 To a stirred solution of 5-(3-Ethylamino-4-nitro-benzylidene)-thiazolidine-2,4-dione in THF, a solution of sodium hydrosulfite (3 eq.) in water was slowly added followed by an aqueous solution of  $K_2CO_3$ . The reaction mixture was refluxed over night. THF was removed *in vacuo* and residue extracted with ethyl acetate. The organic layer was dried on  $Na_2SO_4$  and the solvent evaporated to give the corresponding aniline derivative, which was
- 10 used without any further purification.

- The following intermediates were synthesized in a similar way using the suitable amines as nucleophiles as described in step IV of intermediate 36. The so-obtained 3-alkylamino-4-nitro-benzylidene)-thiazolidine-2,4-diones were reduced as described in step V of
- 15 intermediate 36 affording 3-alkylamino-4-amino-benzylidene)-thiazolidine-2,4-diones.

N°.	Intermediate	M/Z ESI:(M+ 1)
37	5-[4-Amino-3-(4-phenyl-butylamino)-benzylidene]-thiazolidine-2,4-dione	368.2
38	5-{4-Amino-3-[2-(4-trifluoromethyl-phenyl)-ethylamino]-benzylidene}-thiazolidine-2,4-dione	408.12
39	5-{4-Amino-3-[2-(4-hydroxy-phenyl)-ethylamino]-benzylidene}-thiazolidine-2,4-dione	356.13
40	4-[2-Amino-5-(2,4-dioxo-thiazolidin-5-ylidenemethyl)-phenylamino]-cyclohexanecarboxylic acid methyl ester	376.35
41	5-{4-Amino-3-[2-(1H-indol-3-yl)-ethylamino]-benzylidene}-thiazolidine-2,4-dione	409.21
42	5-{4-Amino-3-[(1-methyl-1H-pyrazol-4-ylmethyl)-amino]-benzylidene}-thiazolidine-2,4-dione	331.1

43	5-{4-Amino-3-[2-(3,4-dimethoxy-phenyl)-ethylamino]-benzylidene}-thiazolidine-2,4-dione	400.21
44	5-[4-Amino-3-(4-trifluoromethyl-benzylamino)-benzylidene]-thiazolidine-2,4-dione	394.15
45	4-[2-Amino-5-(2,4-dioxo-thiazolidin-5-ylidenemethyl)-phenylamino]-cyclohexanecarboxylic acid	362.17
46	5-(4-Amino-3-isobutylamino-benzylidene)-thiazolidine-2,4-dione	292.22
47	5-[4-Amino-3-(2-benzo[1,3]dioxol-4-yl-ethylamino)-benzylidene]-thiazolidine-2,4-dione	384.26
48	5-{4-Amino-3-[2-(2-phenoxy-phenyl)-ethylamino]-benzylidene}-thiazolidine-2,4-dione	432.28
49	5-[4-Amino-3-(3,3-diphenyl-propylamino)-benzylidene]-thiazolidine-2,4-dione	430.27
50	5-(4-Amino-3-prop-2-ynylamino-benzylidene)-thiazolidine-2,4-dione	274.21
51	5-[4-Amino-3-(2-methoxy-benzylamino)-benzylidene]-thiazolidine-2,4-dione	356.23
52	5-{4-Amino-3-[(furan-3-ylmethyl)-amino]-benzylidene}-thiazolidine-2,4-dione	316.21
53	5-(4-Amino-3-propylamino-benzylidene)-thiazolidine-2,4-dione	278.16
54	5-{4-Amino-3-[2-(4-phenoxy-phenyl)-ethylamino]-benzylidene}-thiazolidine-2,4-dione	432.23

Intermediate 55: Quinoxaline-6-carbaldehyde



Step I: Quinoxaline-6-carbonyl chloride

- 5 In a 1 l 3 neck flask was placed Quinoxaline-6-carboxylic acid (20.2 g) in 500 ml of THF. To this solution was slowly added thionylchloride (42ml, 5eq.). The reaction mechanically

stirred was warmed up to reflux and followed by HPLC quenching the sample with  $\text{NH}_4\text{OH}$ . After 3h at reflux no more starting material was present, the solvent was removed under reduced pressure and  $\text{SOCl}_2$  was chased with toluene 3 times. The solid was suspended in 100 ml EtOAc and filtered to obtain 23.47g of a beige solid.

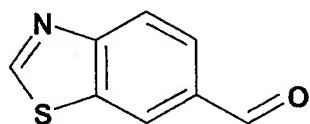
5 HPLC: 1.114 min.  $^1\text{H}$  NMR ( $\text{DMSO-d}_6$ )  $\delta$  9.01-7.40 (m, 5H).

#### Step I: Quinoxaline-6-carbaldehyde

In a 11 3-neck flask under argon was placed Quinoxaline-6-carbonyl chloride in 600ml of DME. To this solution was added lithium tri-tert-butoxyaluminumhydride (1 Eq.) at  $-78^\circ\text{C}$  over 1.5 h. The reaction was kept at that temperature for 5h. Then ice was added, and the  
10 reaction was diluted with AcOEt and filtrated over celite. The two layers were separated and the organic phase was washed with  $\text{NaHCO}_3$  sat. Quinoxaline-6-carbaldehyde was obtained upon evaporating the solvent in 73% yield as yellowish solid.

HPLC: 1.49 min. LC-MS: M/Z ESI: 0.81 min, 159.37(M+1).  $^1\text{H}$  NMR ( $\text{CDCl}_3$ )  $\delta$  10.28 (s, 1H), 8.97 (s, 2H), 8.61 (s, 1H), 8.27 (q, 6Hz, 9Hz, 2H).

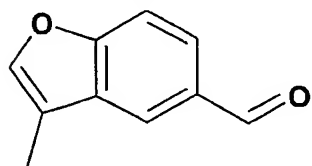
#### 15 Intermediate 56: Benzothiazole-6-carbaldehyde



This intermediate was synthesized as seen in the synthesis of intermediate 55 starting from Benzothiazole-6-carboxylic acid. The overall yield was 38%.

HPLC: 1.92 min. LC-MS: M/Z ESI: 0.97 min, 164.27 (M+1).  $^1\text{H}$  NMR ( $\text{DMSO-d}_6$ )  $\delta$   
20 10.1 (s, 1H), 9.60 (s, 1H), 8.60 (s, 1H), 8.20 (m, 1H), 8.10 (d, 1H).

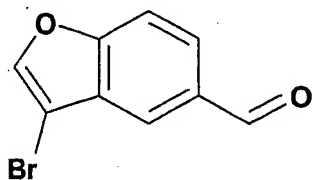
#### Intermediate 57: 3-Methyl-benzofuran-5-carbaldehyde



This intermediate was accessed through the same route as intermediate 1 using Ethyl-2-acetyl-4-bromophenoxy acetate as starting material. Overall yield 50%.

LC-MS: M/Z ESI: 1.55 min, 161.34 (M+1).  $^1\text{H}$  NMR (DMSO- $d_6$ )  $\delta$  10.1 (s, 1H), 8.21 (d,  $J=1.5\text{Hz}$  1H), 7.92 (d,  $J=1.3\text{Hz}$ , 1H), 7.88-7.84 (dd,  $J=1.6\text{Hz}$ , 1H), 7.73-7.71 (d,  $J=8.5\text{Hz}$ , 1H), 2.25 (s, 3H).

Intermediate 58: 3-Bromo-benzofuran-5-carbaldehyde



Step I: 2,3-Dibromo-2,3-dihydro-benzofuran-5-carbaldehyde

Intermediate 1 (2g, 13.7mmol) was dissolved in 10ml  $\text{CHCl}_3$  and cooled to  $-10^\circ\text{C}$ . To this was added a solution of  $\text{Br}_2$  in  $\text{CHCl}_3$  (1.55 eq.,  $c=4.162\text{mol/l}$ ). The reaction mixture turned dark and was allowed to reach r.t. during 1h. HPLC indicated complete addition of bromine. The solvent and remaining bromine were evaporated under reduced pressure affording a reddish oil (4.1g = 90%), which was used for the next step without further purification.

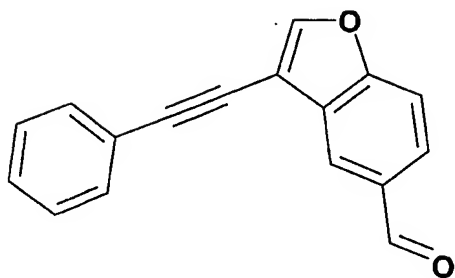
HPLC: 3.43 min

Step II: 3-Bromo-1-benzofuran-5-carbaldehyde

To a solution of 2,3-dibromo-2,3-dihydro-1-benzofuran-5-carbaldehyde (4.1g) in dry ethanol (15mL) was added a solution of KOH (2.2 eq.) in dry ethanol (14mL) and refluxed at  $70^\circ\text{C}$  for 1h. The reaction mixture was cooled, diluted with water and extracted with EtOAc (3x50mL). The organic layer was washed with water, brine and dried. The solvent was removed under vacuum and the residue was purified by flash chromatography (pet. ether/EtOAc 99.5:0.5) to give the title compound as a pale yellow solid (2.91g (80%pure), yield=78%).

HPLC: 3.35 min.  $^1\text{H}$  NMR (DMSO- $d_6$ , 300 MHz)  $\delta$  10.12 (s, 1H), 8.47 (s, 1H), 8.14 (d,  $J=1.5\text{ Hz}$ , 1H), 7.97 (dd,  $J=8.6, 1.5\text{ Hz}$ , 1H), 7.87 (d,  $J=8.6\text{ Hz}$ , 1H).

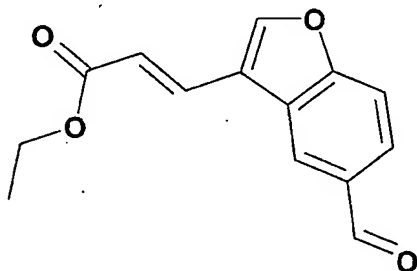
Intermediate 59: 3-Phenylethynyl-benzofuran-5-carbaldehyde



In a dry flask 3-Bromo-1-benzofuran-5-carbaldehyde (1g, 4.4mmol) were dissolved in anhydrous THF (50 ml). To this was added under Argon Bis (triphenylphosphine) palladium(II) chloride (160mg, 0.2mmol), TEA (2.81mL, 5eq.), CuI (40mg, 0.2mmol) and Phenylacetylene (897mg, 8.8mmol). The reaction was heated at 55°C for 2 days. The crude was filtered through celite and purified on silicagel using as eluent cyclohexan-ethyl acetate (7-3) affording 680mg (yield: 56%)

HPLC: 4.71 min. <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 10.14 (s, 1H), 8.64 (s, 1H), 8.38 (s, 1H), 7.97 (dd, *J*=1.5Hz, 8.3Hz, 1H), 7.90 (d, *J*=8.6Hz, 1H), 7.65 (m, 2H), 7.46 (m, 3H).

10 Intermediate 60: 3-(5-Formyl-benzofuran-3-yl)-acrylic acid ethyl ester

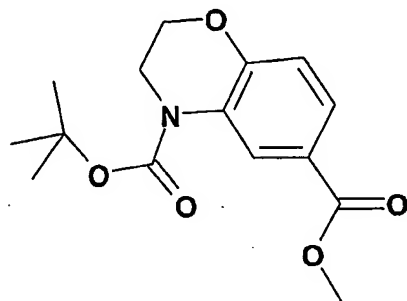


In a sealed tube 3-Bromo-1-benzofuran-5-carbaldehyde (500mg, 2.22mmol) was dissolved in 7 ml of ACN. To this solution was added PPh<sub>3</sub> (1.16g, 4.44mmol), Pd(II)acetate (500mg, 2.2mmol), Et<sub>3</sub>N (0.73mL, 5.55mmol) and finally acrylic acid ethyl ester (2.41ml, 22mmol). The tube was sealed and the reaction was heated at 120°C for one hour. The crude was filtered on celite to eliminate inorganic contaminations. The solvents were evaporated and the crude was purified by silicagel chromatography using cyclohexane-AcOEt 95-5 to 50-50. A pale yellow solid was obtained (400mg, yield:42%).

HPLC: 3.69 min. <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 10.15 (s, 1H), 8.70 (s, 2H), 7.97 (d, *J*=9Hz 1H), 7.88 (s, 1H), 7.82 (s, 1H), 6.76 (d, *J*=15Hz, 1H), 4.23 (q, *J*=6Hz, 12Hz, 2H), 1.28 (t, *J*=9Hz, 3H).



Intermediate 61: 2,3-Dihydro-benzo[1,4]oxazine-4,6-dicarboxylic acid 4-tert-butyl ester 6-methyl ester



Step I: 3-Amino-4-hydroxy-benzoic acid methyl ester

- 5 To a 2000ml three-necked flask containing 3-Nitro-4-hydroxy-benzoic acid methyl ester (43g, 218mmol) in MeOH (860ml; 20vols) was added palladium on carbon in water (2g in 10ml of water). Ammonium formate (68.76g, 5eq.) was added in a single portion under stirring. After 2 to 3 minutes a suspension was observed, and temperature rised from 20°C to 30°C. Ice bath was used to cool reaction mixture to 20°C and the reaction was stirred at
- 10 20°C for 40minutes until completion (no more yellow color). Reaction mixture was filtered on silica plug, rinsed with MeOH, and the filtrate was concentrated under vacuum to give a green oil which was taken up in ethyl acetate (400ml). The organic phase was washed twice with water, dried over MgSO<sub>4</sub>, filtered and concentrated to give a cream solid m=31.35g (86%).
- 15 LC-MS: M/Z ESI: 0.81 min, 168.37 (M+1)

Step II: 3,4-Dihydro-2H-benzo[1,4]oxazine-6-carboxylic acid methyl ester\*hydrochloride

- To a 2000ml three-necked flask under N<sub>2</sub> containing 3-Amino-4-hydroxy-benzoic acid methyl ester (31.35g, 187mmol) in anhydrous DMF (630ml; 20vols) at RT, was added K<sub>2</sub>CO<sub>3</sub> (103g, 4eq.) in one portion followed by 1,2dibromoethane (65ml, 4eq.) in one
- 20 portion. The reaction mixture was stirred at 70°C for 12h. Temperature was allowed to cool down to RT, and HCl1N was added until pH=8, and extraction was performed using diethyl ether (3\*200ml). The organic phase was washed with water (2\*200ml) and dried over MgSO<sub>4</sub> and concentrated to afford a brown red oil with solid, which was taken up again in diethyl ether (450ml) and THF (50ml) and filtered to remove a white solid. To the
- 25 filtrate was added HCl1N, and diethyl ether (130ml) was added, suspension was stirred at

RT for 5 minutes and filtered to give 27.6g of crude product. The aqueous phases were again extracted with ethyl acetate to afford additional 6.23g of product. The combined fractions (32g) were recrystallised from EtOH (420ml; 13vols) to give after filtration and drying a white powder (19.47g (16.37g free base)), yield = 40%.

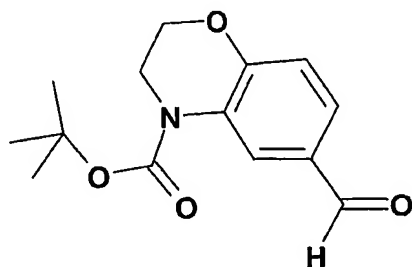
5 HPLC: 1.954 min. LC-MS: M/Z ESI: 1.27 min, 194.45 (M+1).

Step III: 2,3-Dihydro-benzo[1,4]oxazine-4,6-dicarboxylic acid 4-tert-butyl ester 6-methyl ester

To a 500ml three-necked flask containing 3,4-Dihydro-2H-benzo[1,4]oxazine-6-carboxylic acid methyl ester\*hydrochloride in suspension in THF (145ml; 10 vols) under N<sub>2</sub>, DIEA  
10 (27ml, 2.5eq.) was added in one portion at RT and partial solubilisation was observed. Boc anhydride (16.4g, 1.2 eq.) was added in one portion and the reaction was stirred at 65°C for 5 days. During that time several small portions of 0.2 eq. of Boc<sub>2</sub>O and DIEA were added. THF was removed under vacuum and the residue was taken up in DCM 150ml. The organic phase was washed with a saturated solution of NaHCO<sub>3</sub> and then with brine. After  
15 drying over MgSO<sub>4</sub> and filtration, volatiles were removed under vacuum and the residue was recrystallised from EtOH (80ml) to give cream crystals (14.8g, 76%).

HPLC: 4.038 min. <sup>1</sup>H NMR (CDCl<sub>3</sub>) δ 8.49 (s, 1H), 7.68 (dd, J=3Hz, 9Hz, 1H), 6.89 (d, J=9Hz, 1H), 4.30 (q, J=3Hz, 9Hz, 2H), 3.89 (m, 5H), 1.62 (s, 9H).

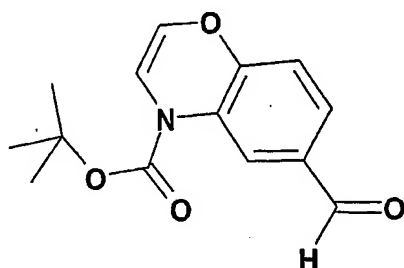
20 Intermediate 62: 6-Formyl-2,3-dihydro-benzo[1,4]oxazine-4-carboxylic acid tert-butyl ester



This intermediate was accessed through oxido-reduction as described for intermediate 5.

HPLC: 3.727 min. LC-MS: M/Z ESI: 1.81 min, 264.34 (M+1). <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 9.83 (s, 1H), 8.35 (s, 1H), 7.53 (d, J=6Hz, 1H), 7.05 (d, J=9Hz, 1H), 4.31 (t, J=3Hz, 2H),  
25 3.83 (t, J=6Hz, 2H), 1.50 (s, 9H).

Intermediate 63: 6-Formyl-benzo[1,4]oxazine-4-carboxylic acid tert-butyl ester



Step I: 2,3-Dibromo-2,3-dihydro-benzo[1,4]oxazine-4,6-dicarboxylic acid 4-tert-butyl ester 6-methyl ester

- 5 To a solution of 2,3-Dihydro-benzo[1,4]oxazine-4,6-dicarboxylic acid 4-tert-butyl ester 6-methyl ester (500mg, 1.7mmol) in dry carbon tetrachloride (20ml) was added N-Bromosuccinimide (667mg, 3.75mmol) and a catalytic amount of benzoylperoxide. The resulting mixture was stirred and heated with a bulb lamp (100W) at reflux for 45min. The mixture was allowed to cool and the succinimide was filtered off. The filtrate was
- 10 evaporated to yield an oil (767mg, 99%) sufficiently pure to be used for the next step.  
HPLC: 3.978 min

Step II: Benzo[1,4]oxazine-4,6-dicarboxylic acid 4-tert-butyl ester 6-methyl ester

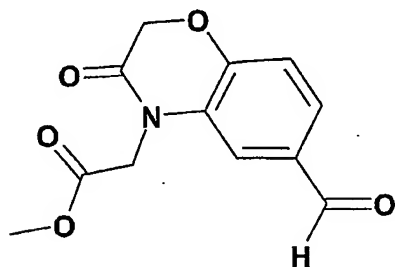
- 2,3-Dibromo-2,3-dihydro-benzo[1,4]oxazine-4,6-dicarboxylic acid 4-tert-butyl ester 6-methyl ester (767mg, 1.7mmol) from proceeding step was stirred in acetone (14ml) at RT
- 15 for 2h with NaI (1.27g, 8.5mmol). The solvent was removed, EtOAc, water and 1 M sodium thiosulfate were added. After separating phases the organic layer was washed with brine. The solvent was concentrated and the crude was purified on silica gel using CH/EtOAc 7:3 to obtain a colorless oil (456mg, 92%).  
HPLC: 4.386 min.

20 Step III: 6-Hydroxymethyl-benzo[1,4]oxazine-4-carboxylic acid tert-butyl ester

Step IV: 6-Formyl-benzo[1,4]oxazine-4-carboxylic acid tert-butyl ester

Step III and IV were carried out according to the synthesis of intermediate 5.  
HPLC: 3.388 min.

Intermediate 64: (6-Formyl-3-oxo-2,3-dihydro-benzo[1,4]oxazin-4-yl)-acetic acid methyl ester



Step I: Methyl-3-amino-4-hydroxybenzoate

- 5 To a solution of 3-amino-4-hydroxybenzoic acid (100g, 0.65mol) in methanol (1.5L) was added thionylchloride (233g, 1.96mol) drop-wise at 5-10°C with stirring and allowed to reflux at 65°C for 16h. Excess methanol and thionylchloride was distilled off and crude dissolved in ethylacetate (500mL). The organic layer was washed with 5% aqueous NaHCO<sub>3</sub> solution, water, brine and dried. The solvent was removed under vacuum to give
- 10 methyl-3-amino-4-hydroxybenzoate (105g, 95%).

Step II: Methyl-3-oxo-3,4-dihydro-2H-1,4-benzoxazin-6-carboxylate

- To a mixture of methyl-3-amino-4-hydroxybenzoate (105g, 0.62mol) and benzyltriethylammonium chloride (142g, 0.62mol) in dry CHCl<sub>3</sub> (1.5L) was added
- 15 NaHCO<sub>3</sub> (211g, 2.5mol) with stirring. The reaction mixture was cooled to -5°C, added chloroacetylchloride (85g, 0.75mol) in dry CHCl<sub>3</sub> (350mL) over a period of 1.5h at the same temperature. The reaction mixture was then heated to 55°C for 16h. The solvent was removed under vacuum, added water (3L) and filtered off the solid. The solid product was dried and recrystallised from ethanol to give methyl-3-oxo-3,4-dihydro-2H-1,4-
- 20 benzoxazin-6-carboxylate (108g, 83%).

Step III: 6-(Hydroxymethyl)-2H-1,4-benzoxazin-3(4H)-one

A solution of methyl-3-oxo-3,4-dihydro-2H-1,4-benzoxazin-6-carboxylate (30g, 0.145mol) in dry CH<sub>2</sub>Cl<sub>2</sub> (500mL) was cooled to -78°C and added DIBAL-H (51g, 0.36mol) over a period of 45min and then stirred at the same temperature for 14h. The reaction mixture was

quenched with 1.5N HCl and filtered off the solid product. The solid compound was dried under vacuum to give 6-(hydroxymethyl)-2H-1,4-benzoxazin-3(4H)-one (18g, 69%).

Step IV: TBDMS-6-(hydroxymethyl)-2H-1,4-benzoxazin-3(4H)-one

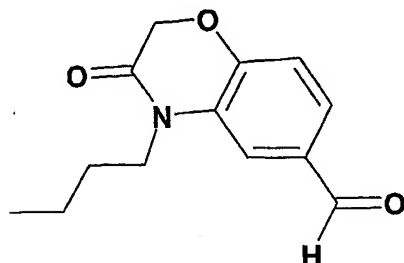
To a solution of 6-(hydroxymethyl)-2H-1,4-benzoxazin-3(4H)-one (18g, 0.10mol) in dry DMF (250mL) was added imidazole (13.7g, 0.2mol) and stirred at 0°C for 30min. To the  
5 above reaction mixture was added TBDMSiCl (23g, 0.15mol) in portions and stirred at RT for 4h. The reaction mixture was diluted with water and filtered off the solid obtained. The solid was dried under vacuum to give TBDMS-6-(hydroxymethyl)2H-1,4-benzoxazin-3(4H)-one (24.5g, 83%).

Step V: Methyl-[6-(hydroxymethyl)-3-oxo-2,3-dihydro-4H-1,4-benzoxazin-4-yl]acetate

To a suspension of NaH (0.3g, 0.01mol) in dry DMF (15mL) was added TBDMS-6-(hydroxymethyl)2H-1,4-benzoxazin-3(4H)-one (2g, 0.0068mol) at 0°C with stirring and allowed to stir at RT for 2h. The reaction mixture was cooled to 0°C, added  
methylchloroacetate (1g, 0.0088mol) and stirred at RT for 12h. The reaction mixture was  
15 further cooled to 0°C, added 50mL of 1.5N HCl solution and stirred at RT for 12h. The reaction mixture was diluted with water (200mL), extracted with ethylacetate (3x150mL). The combined organic layer was washed with 10% aqueous NaHCO<sub>3</sub> solution, brine and dried. The solvent was removed under vacuum and crude purified by column chromatography over silica gel (CHCl<sub>3</sub>/Methanol, 99.5:0.5) to give methyl-[6-  
20 (hydroxymethyl)-3-oxo-2,3-dihydro-4H-1,4-benzoxazin-4-yl]acetate (1.2g, 70%).

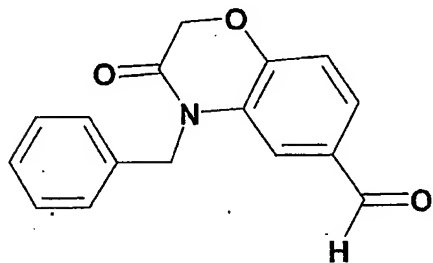
Step VI: Methyl-[6-(Formyl)-3-oxo-2,3-dihydro-4H-1,4-benzoxazin-4-yl]acetate

A mixture of PCC (4.2g, 0.019mol) and celite (4g) in dry CH<sub>2</sub>Cl<sub>2</sub> (100mL) was cooled to 0°C and slowly added a solution of methyl-[6-(hydroxymethyl)-3-oxo-2,3-dihydro-4H-1,4-benzoxazin-4-yl]acetate (1.2g, 0.0048mol) in CH<sub>2</sub>Cl<sub>2</sub> (30mL) under N<sub>2</sub>. The reaction  
25 mixture was stirred at RT for 2h, passed through celite, washed with CH<sub>2</sub>Cl<sub>2</sub> (50mL) and concentrated to give crude product, which was purified on silica gel affording 1.05g (87%).  
LC-MS: M/Z ESI: 1.15 min, 250.41 (M+1). <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 9.88 (s, 1H), 7.65-7.60 (m, 2H), 7.24 (d, J=8.1Hz, 1H), 4.85 (d, J=9.9Hz, 4H), 3.71 (s, 3H).

Intermediate 65: 4-Butyl-3-oxo-3,4-dihydro-2H-benzo[1,4]oxazine-6-carbaldehyde

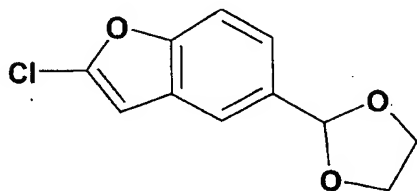
This intermediate was synthesized according to the synthesis of intermediate 2. Overall yield 33%.

- 5 LC-MS: M/Z ESI: 1.60 min, 234.35 (M+1).  $^1\text{H}$  NMR (DMSO- $d_6$ )  $\delta$  7.66 (d,  $J=0.7\text{Hz}$ , 1H), 7.58 (dd,  $J=1.7\text{Hz}$ , 8.1Hz, 1H), 7.18 (d,  $J=8.2\text{Hz}$ , 1H), 4.77 (s, 2H), 3.96 (t,  $J=7.3\text{Hz}$ , 1H), 1.61-1.51 (m, 3H), 1.97-1.27 (m, 3H), 0.91 (t,  $J=7.3\text{Hz}$ , 3H).

Intermediate 66: 4-Benzyl-3-oxo-3,4-dihydro-2H-benzo[1,4]oxazine-6-carbaldehyde

- 10 This intermediate was synthesized according to the synthesis of intermediate 2. Overall yield 29%.

$^1\text{H}$  NMR (DMSO- $d_6$ )  $\delta$  9.78 (s, 1H), 7.58 (dd,  $J=1.5\text{Hz}$ , 7.9Hz, 1H), 7.47 (d,  $J=1.9\text{Hz}$ , 7.40-7.18 (m, 6H), 5.22 (s, 2H), 4.95 (s, 2H), 3.3 (d,  $J=7.2\text{Hz}$ , 1H).

Intermediate 67: 2-Chloro-5-[1,3]dioxolan-2-yl-benzofuran

15

Step I: 5-[1,3]Dioxolan-2-yl-benzofuran

A mixture of benzofuran-5-carbaldehyde (150mg, 1.03mmol), ethylene glycol (230ul, 4eq), trimethyl orthoformate (123ul, 1.1eq) and tetrabutylammonium tribromide (49mg,

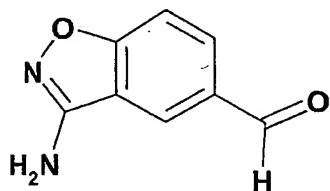
0.1 eq) was stirred at room temperature for one night. Some starting material could be detected by TLC. However, the reaction mixture was poured into saturated  $\text{NaHCO}_3$  solution and the product was extracted with ethyl acetate. Combined organic layers were dried over anhydrous sodium sulfate, filtrated and concentrated to give a crude product, which was purified by flash chromatography using cyclohexane/ethyl acetate 20:0.75 as solvents. The title compounds was obtained in 36% yield (70 mg).

LC-MS: M/Z ESI: 1.51 min, 191.30 (M+1).

Step II: 2-Chloro-5-[1,3]dioxolan-2-yl-benzofuran

5-[1,3]Dioxolan-2-yl-benzofuran (50mg, 0.26mmol) was dissolved in THF (2 mL) and the solution was cooled down to  $-78^\circ\text{C}$ . Butyl lithium (180uL, 1.1eq.) was added dropwise. This mixture was stirred 30 min at  $25^\circ\text{C}$ . Then the reaction mixture was cooled down to  $-78^\circ\text{C}$  and NCS (39mg, 1.1eq.) dissolved in 1 mL THF was added dropwise to the reaction mixture. After 1h30 at  $-78^\circ\text{C}$  only small amount of starting material could be detected. The temperature was increased slowly to room temperature overnight. Water and ethyl acetate were added to the mixture and the aqueous layer was extracted 3 times. Combined organic phases was dried over  $\text{MgSO}_4$ , filtrated and evaporated to give 2-Chloro-5-[1,3]dioxolan-2-yl-benzofuran (48.1 mg, 81%) sufficiently pure to be used in the next step. LC-MS: M/Z ESI: 1.77 min, 225.23 (M+1).

Intermediate 68: 3-Amino-benzo[d]isoxazole-5-carbaldehyde



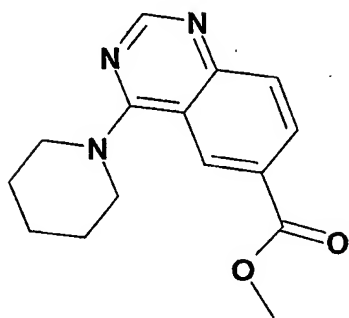
Kaiser oxime resin (Novabiochem 01-64-0188) (250mg) was washed with DCM and THF (3 times 5min), 2ml of THF was added followed by the addition of 300ul of potassium-tert.butoxide (1M in THF, 1.2eq.) at r.t.. The resin turned orange and was shaken in the Quest210™ for 15'. 2-Fluoro-5-formyl-benzonitrile (75mg, 2eq.) in 1ml THF was added and the reaction was heated at  $55^\circ\text{C}$  for 12h. The resin was washed with DCM, MeOH,

water (each 2 x 5 minutes) and MeOH (4 x 5 min). The resin was dried at 40°C with a flow of Argon for 30' before cleaving.

The so dried resin was treated with TFA/5N HCl 4:1 (2.5 ml) for 2h at 55°C. The solution was collected in 20ml vials and the resin was washed twice with 4ml of DCM. The collected fractions were evaporated with the Genevac HT4 to dryness affording: 37 mg (92%) of pure 3-Amino-benzo[d]isoxazole-5-carbaldehyde.

HPLC: 1.47 min. LC-MS: M/Z ESI: 0.82 min, 163.26 (M+1).

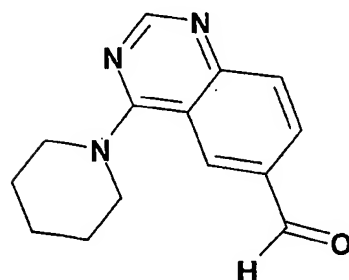
Intermediate 69: 4-Piperidin-1-yl-quinazoline-6-carboxylic acid methyl ester



- 10 This intermediate was prepared according to the synthesis of intermediate 8 starting from 4-Chloro-quinazoline-6-carboxylic acid methyl ester (intermediate 7).

HPLC: 1.81 min. LC-MS: M/Z ESI: 1.78 min, 272.32(M+1).

Intermediate 70: 4-Piperidin-1-yl-quinazoline-6-carbaldehyde

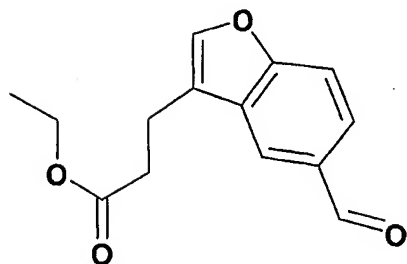


- 15 This intermediate was prepared according to the synthesis of intermediate 5 starting from 4-Piperidine-quinazoline-6-carboxylic acid methyl ester (intermediate 71).

HPLC: 1.36 min. LC-MS: M/Z ESI: 1.40 min, 242.32(M+1).

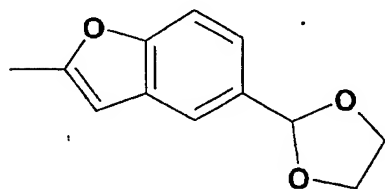
Intermediate 71: 3-(5-Formyl-benzofuran-3-yl)-propionic acid ethyl ester





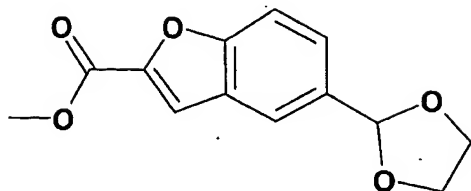
100mg of 3-(5-Formyl-benzofuran-3-yl)-acrylic acid ethyl ester (intermediate 62) were dissolved in EtOAc in the presence of Palladium on charcoal and Argon. To this was connected a H<sub>2</sub>-balloon and hydrogenation was carried out for 12h. The palladium was filtered off and the solvents were evaporated affording pure title compound (80mg, 80%).  
HPLC: 3.53 min. LC-MS: M/Z ESI: 1.68 min, 247.25 (M+1).

Intermediate 72: 2-Methyl-5-[1,3]dioxolan-2-yl-benzofuran



5-[1,3]Dioxolan-2-yl-benzofuran (50mg, 0.26mmol) was dissolved in THF (2 mL) and the solution was cooled down to -78°C. Butyl lithium (180uL, 1.1eq.) was added dropwise. This mixture was stirred 30 min at 25°C. Then the reaction mixture was cooled down to -78°C and iodomethane (18.1 uL, 1.1eq.) dissolved in 1 mL THF was added dropwise to the reaction mixture. The temperature was increased slowly to room temperature overnight. Despite some starting material was detected, water and ethyl acetate were added to the mixture and the aqueous layer was extracted 3 times. Combined organic phases was dried over MgSO<sub>4</sub>, filtrated and evaporated to give 2-methyl-5-[1,3]dioxolan-2-yl-benzofuran (41.2 mg, 70%) sufficiently pure to be used in the next step.  
LC-MS: M/Z ESI: 1.71 min, 205.34 (M+1).

Intermediate 73: 5-[1,3]Dioxolan-2-yl-benzofuran-2-carboxylic acid methyl ester



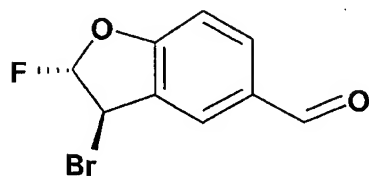
5-[1,3]Dioxolan-2-yl-benzofuran (50mg, 0.26mmol) was dissolved in THF (2 mL) and the solution was cooled down to  $-78^{\circ}\text{C}$ . Butyl lithium (180uL, 1.1eq.) was added dropwise.

This mixture was stirred 30 min at  $25^{\circ}\text{C}$ . Then the reaction mixture was cooled down to  $-$

5  $78^{\circ}\text{C}$  and methyl cyanoformate (23 uL, 1.1eq.) dissolved in 1 mL THF was added dropwise to the reaction mixture. After 1h30 only small amount of starting material was detected and two major compounds were formed (expected product/dimer 73:27). The temperature was increased slowly to room temperature overnight. Water and ethyl acetate were added to the mixture and the aqueous layer was extracted 3 times. Combined organic  
10 phases was dried over  $\text{MgSO}_4$ , filtrated and evaporated to give the 5-[1,3]Dioxolan-2-yl-benzofuran-2-carboxylic acid methyl ester (31.9 mg, 44%) mixed with the dimer (expected product/dimer 46:54). The mixture was used directly in the next step.

LC-MS: M/Z ESI: 1.54 min, 249.26 (M+1) and 1.88 min, 407.20 (M+1, Dimer).

15 Intermediate 74: 3-Bromo-2-fluoro-benzofuran-5-carbaldehyde



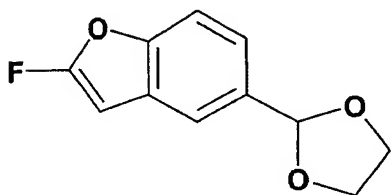
Benzofuran-5-carbaldehyde (100 mg, 0.68 mmol) in ether (1 mL) was added to a cold solution ( $-78^{\circ}\text{C}$ ) of NBS (158 mg, 1.3 eq) and pyridinium poly(hydrogen fluoride) 70% (0.850 mL) in ether (4 mL) in a polypropylene tube. The reaction was allowed to warm up

20 to room temperature overnight. The reaction mixture was poured into ice water and extracted with ether. The ether phase was washed with aqueous bicarbonate, dried over sodium sulfate, filtrated and evaporated to give 3-bromo-2-fluoro-benzofuran-5-carbaldehyde (141.6 mg). It was purified on reverse phase HPLC (solvents gradient  $\text{H}_2\text{O}/\text{CH}_3\text{CN}$  0.1% TFA) affording the title compound (62 mg, 37%), which was used in  
25 the next step.

LC-MS: M/Z ESI: 1.56 min. HPLC=3.11 min (99.34%).  $^1\text{H}$  NMR: (DMSO- $d_6$ )  $\delta$  9.94 (s, 1H), 8.09 (d, 1H,  $^3J=1.8$  Hz), 7.99 (dd, 1H,  $^3J=8.4$ , 1.8 Hz), 7.38 (d, 1H,  $^3J=8.4$  Hz), 6.87 (d, 1H,  $^2J_{\text{H-F}}=59$  Hz), 6.01 (d, 1H,  $^3J_{\text{H-F}}=15.1$  Hz).  $^{19}\text{F}$  NMR: (DMSO- $d_6$ )  $\delta$  -114.80, -114.88.

5

Intermediate 75: 2-Fluoro-5-[1,3]dioxolan-2-yl-benzofuran

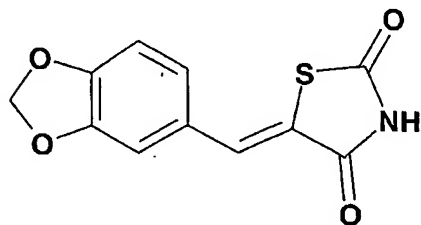


5-[1,3]Dioxolan-2-yl-benzofuran (50mg, 0.26mmol) was dissolved in THF (2 mL) and the solution was cooled down to  $-78^\circ\text{C}$ . Butyl lithium (180uL, 1.1eq.) was added dropwise.

10 This mixture was stirred 30 min at  $25^\circ\text{C}$ . Then the reaction mixture was cooled down to  $-78^\circ\text{C}$  and N-fluorodibenzenesulfonamide (91 mg, 1.1eq.), dissolved in 1 mL THF, was added dropwise to the reaction mixture. The mixture was stirred overnight between  $-78^\circ\text{C}$  and room temperature. Water and ethyl acetate were added to the mixture and the aqueous layer was extracted 3 times. Combined organic phases was dried over  $\text{MgSO}_4$ , filtrated and  
15 evaporated, to give the 2-Fluoro-5-[1,3]dioxolan-2-yl-benzofuran (75 mg) mixed with side products. However it was sufficiently pure to be used for the next step.

The following examples have been synthesized:

Example 1: Preparation of 5-(1,3-benzodioxol-5-ylmethylene)-1,3-thiazolidine-2,4-dione



20

In a 100ml round bottom flask were placed 20g of thiazolidine, 15.6g of piperonal and 7.7g of beta-alanine in 80ml of acetic acid. The reaction was stirred for 3h at  $100^\circ\text{C}$  and then slowly cooled to room temperature, while the desired condensation product crystallized. The crystals were filtered, washed with acetic acid (rt.) and water than recrystallized from

DME (25ml), affording 28g (84%) of pure 5-(1,3-benzodioxol-5-ylmethylene)-1,3-thiazolidine-2,4-dione. The corresponding potassium salt was obtained via the following route: 5-(1,3-benzodioxol-5-ylmethylene)-1,3-thiazolidine-2,4-dione was suspended in THF, followed by the addition of 1N solution of KOH in water (1.0 eq.). A clear solution has been obtained, which upon lyophilization gave pure potassium salt of 5-(1,3-benzodioxol-5-ylmethylene)-1,3-thiazolidine-2,4-dione.

HPLC: 3.48 min. LC-MS: M/Z ESI: 1.31 min, 248.12 (M-1). NMR (parent): <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 12.5 (br. s, 1H), 7.71 (s, 1H), 7.06-7.16 (m, 3H), 6.12 (s, 2H).

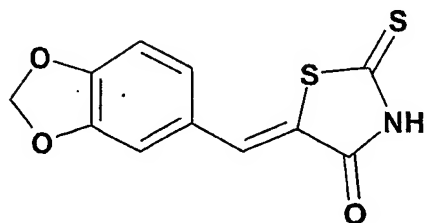
In cases where the final compounds did not crystallize from the reaction solutions, small quantities of water were added, leading to the precipitation of the desired condensation product.

The crude either precipitated pure enough from the reaction mixture, or was recrystallized from an appropriate solvent like DME, methanol, EtOAc or purified by flash-chromatography using EtOAc, cyclohexane mixtures as eluents.

Alternatively the final compounds could be synthesized in a parallel manner according to the following protocol:

In a parallel synthesizer Quest 210™ was placed the corresponding aldehyde, to which was added a mixture of piperidine (17.9 mg/tube) and 2,4-thiazolidinedione (49.2 mg/tube) in DME (2ml/tube). The reactions were stirred for 3h at 120°C and then cooled to room temperature under agitation. 2ml of H<sub>2</sub>O were added. Those compounds, which precipitated were filtered off via the lower manifold. The remaining clear solutions were reduced in volume, followed by the addition of water. The so formed solids were filtered and washed with little amount of DME, affording pure condensation products.

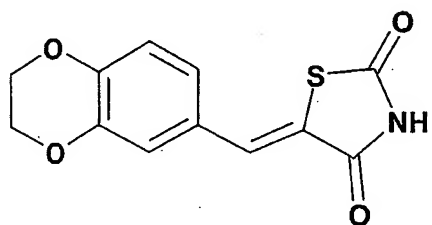
Example 2: Preparation of 5-(1,3-benzodioxol-5-ylmethylene)-2-thioxo-1,3-thiazolidin-4-one



In a 24ml vial was placed 1g of commercially available rhodanine, 1.3g of piperonal and 0.5ml of TEA in 10ml of DME. The reaction was stirred for 5h at 120°C and then cooled to room temperature upon which the final product precipitated. The solid was filtered and washed with DME affording 1.6 g (80%) of orange powder.

- 5 LC-MS: M/Z ESI: 1.46 min, 266.00 (M+1), 264.08 (M-1). NMR (parent): <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 13.75 (br. s, 1H), 7.58 (s, 1H), 7.08-7.18 (m, 3H), 6.14 (s, 2H).

Example 3: Preparation of 5-(2,3-dihydro-1,4-benzodioxin-6-ylmethylene)-1,3-thiazolidine-2,4-dione:

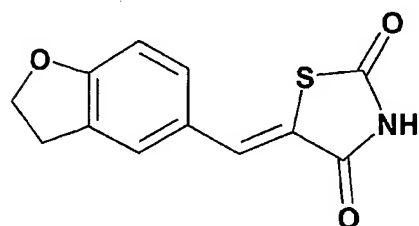


10

Following the general method as outlined in Example 1, starting from 2,3-dihydro-1,4-benzodioxin-6-carbaldehyde and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

- 15 HPLC: 2.58 min. LC-MS: M/Z ESI: 1.32 min, 262.16 (M-1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ 12.52 (br. s, 1H), 7.68 (s, 1H), 7.09 (dd, 2H, J = 1.9, 7.1), 7.00 (d, 1H, J = 9.0Hz), 4.36-4.22 (m, 4H).

Example 4: Preparation of 5-(2,3-dihydro-1-benzofuran-5-ylmethylene)-1,3-thiazolidine-2,4-dione:

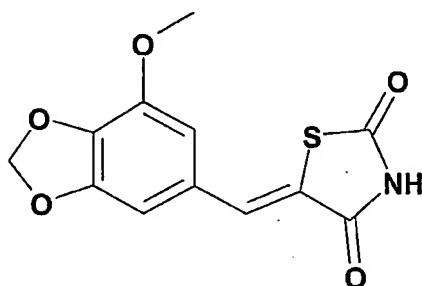


20

Following the general method as outlined in Example 1, starting from 2,3-dihydro-1-benzofuran-5-carbaldehyde and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

HPLC: 3.27 min. LC-MS: M/Z ESI: 1.37 min, 246.18 (M-1).  $^1\text{H}$  NMR: (DMSO- $d_6$ )  $\delta$  9.80 (br. s, 1H), 7.37 (s, 1H), 7.25 (d, 1H,  $J = 8.3$ ), 7.21 (s, 1H), 6.80 (d, 1H,  $J = 8.3\text{Hz}$ ), 4.54 (t, 2H,  $J = 8.85$ ), 3.19 (t, 2H,  $J = 8.85$ )

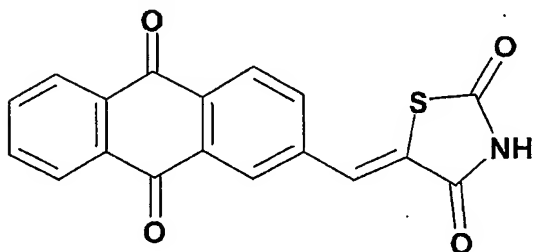
Example 5: Preparation of 5-[(7-methoxy-1,3-benzodioxol-5-yl)methylene]-1,3-thiazolidine-2,4-dione



Following the general method as outlined in Example 1, starting from 7-methoxy-1,3-benzodioxol-5-yl)carbaldehyde and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

HPLC: 3.57 min. LC-MS: M/Z ESI: 1.30 min, 278.07 (M-1).  $^1\text{H}$  NMR: (DMSO- $d_6$ )  $\delta$  12.63 (br. s, 1H), 7.78 (s, 1H), 7.65 (s, 1H), 7.57 (d, 1H,  $J = 8.5\text{Hz}$ ), 7.45 (dd, 2H,  $J = 0.8, 7.6$ ).

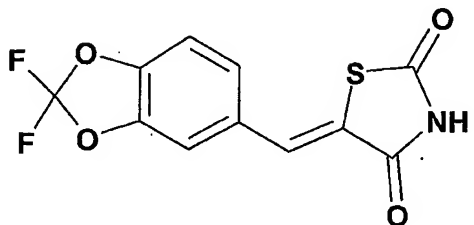
Example 6: Preparation of 5-[(9,10-dioxo-9,10-dihydroanthracen-2-yl)methylene]-1,3-thiazolidine-2,4-dione



Following the general method as outlined in Example 1, starting from (9,10-dioxo-9,10-dihydroanthracen-2-yl)carbaldehyde and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

HPLC: 4.12 min. LC-MS: M/Z ESI: 1.50 min, 334.09 (M-1).

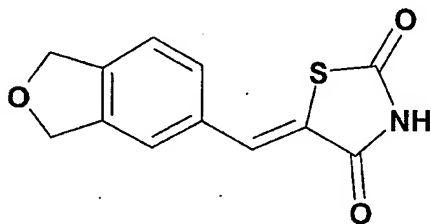
Example 7: Preparation of (5-[(2,2-difluoro-1,3-benzodioxol-5-yl)methylene]-1,3-thiazolidine-2,4-dione



Following the general method as outlined in Example 1, starting from (2,2-difluoro-1,3-benzodioxol-5-yl)carbaldehyde and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

HPLC: 3.85 min. LC-MS (10 min.): M/Z ESI: 3.15 min, 284.11 (M-1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ 12.63 (br. s, 1H), 7.78 (s, 1H), 7.65 (s, 1H), 7.57 (d, 1H, J = 8.5 Hz), 7.45 (dd, 2H, J = 0.8, 7.6)

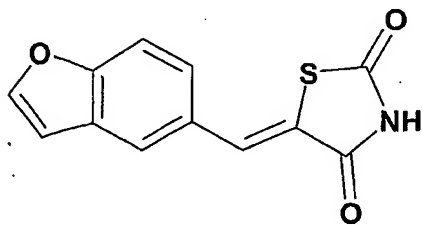
Example 8: Preparation of 5-(1,3-dihydro-2-benzofuran-5-ylmethylene)-1,3-thiazolidine-2,4-dione



Following the general method as outlined in Example 1, starting from 1,3-dihydro-2-benzofuran-5-carbaldehyde (intermediate 4) and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

HPLC: 2.89 min. LC-MS: M/Z ESI: 1.20 min, 246.20 (M-1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ 12.60 (br. s, 1H), 7.80 (s, 1H), 7.56-7.42 (m, 2H), 5.03 (s, 4H)

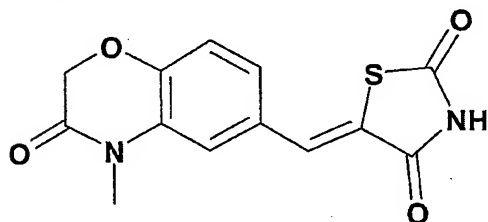
Example 9: Preparation of 5-(1-benzofuran-5-ylmethylene)-1,3-thiazolidine-2,4-dione



Following the general method as outlined in Example 1, starting from 1-benzofuran-5-carbaldehyde (intermediate 1) and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

HPLC: 3.54 min. LC-MS: M/Z ESI: 1.47 min, 244.20 (M-1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ  
12.58 (br. s, 1H), 8.10 (d, 1H, J = 2.2Hz), 7.92 (s, 2H), 7.74 (d, 1H, J = 8.6Hz), 7.57 (d,  
1H, J = 8.6Hz), 7.07 (s, 1H)

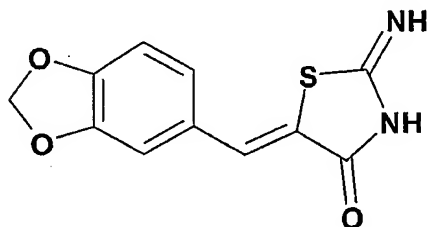
Example 10: Preparation of 5-[(4-methyl-3-oxo-3,4-dihydro-2H-1,4-benzoxazin-6-yl)methylene]-1,3-thiazolidine-2,4-dione



Following the general method as outlined in Example 1, starting from [(4-methyl-3-oxo-3,4-dihydro-2H-1,4-benzoxazin-6-yl)carbaldehyde (intermediate 2) and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

HPLC: 2.79 min. LC-MS: M/Z ESI: 1.19 min, 289.22 (M-1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ  
12.58 (br. s, 1H), 7.81 (s, 1H), 7.41 (s, 1H), 7.13-7.26 (d, 2H), 4.74 (s, 2H), 2.99 (s, 3H)

Example 11: Preparation of 5-(1,3-benzodioxol-5-ylmethylene)-2-imino-1,3-thiazolidine-4-one

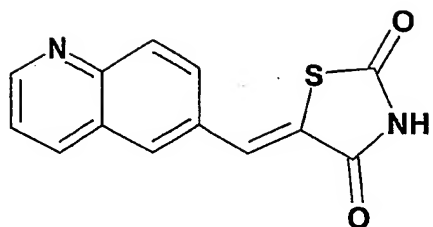


Following the general method as outlined in Example 1, starting from 1,3-benzodioxol-5-carbaldehyde and 2-imino-1,3-thiazolidin-4-one, the title compound was obtained.

HPLC: 2.29 min. LC-MS: M/Z ESI: 1.21 min, 247.25 (M-1).

Example 12: Preparation of 5-Quinolin-6-ylmethylene-thiazolidine-2,4-dione

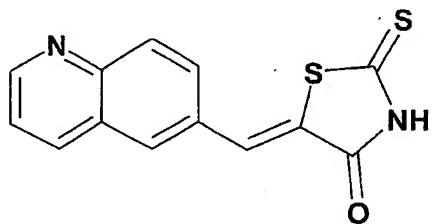




Following the general method as outlined in Example 1, starting from quinoline-6-carbaldehyde (intermediate 5) and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

HPLC: 1.445 min. LC-MS: M/Z ESI: 1.17 min, 257.21 (M+1).  $^1\text{H}$  NMR: (DMSO- $d_6$ )  $\delta$  8.88 (d,  $J=6\text{Hz}$ , 1H), 8.40 (d,  $J=9\text{Hz}$ , 1H), 8.07-7.90 (m, 3H), 7.55 (q,  $J=6\text{Hz}$ , 9Hz, 1H), 7.45 (s, 1H).

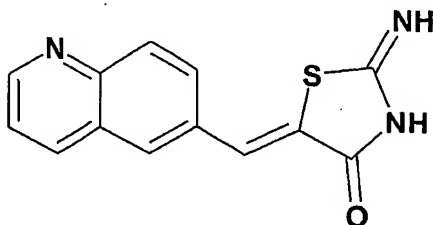
Example 13: 5-Quinolin-6-ylmethylene-2-thioxo-thiazolidin-4-one



Following the general method as outlined in Example 1, starting from quinoline-6-carbaldehyde (intermediate 5) and rhodanine, the title compound was obtained.

HPLC: 2.05 min. LC-MS: M/Z ESI: 1.25 min, 273.14 (M+1).  $^1\text{H}$  NMR: (DMSO- $d_6$ )  $\delta$  14.00 (br. s, 1H), 8.97 (d,  $J=2.3\text{Hz}$ , 1H), 8.23 (d,  $J=9\text{Hz}$ , 1H), 8.10 (d,  $J=9\text{Hz}$ , 1H), 7.95 (d,  $J=9\text{Hz}$ , 1H), 7.79 (s, 1H), 7.61 (q,  $J=3\text{Hz}$ , 9Hz, 1H).

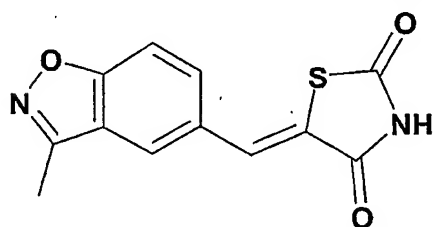
Example 14: 2-Imino-5-quinolin-6-ylmethylene-thiazolidin-4-one



Following the general method as outlined in Example 1, starting from quinoline-6-carbaldehyde (intermediate 5) and 2-imino-1,3-thiazolidin-4-one, the title compound was obtained.

HPLC: 1.16 min. LC-MS: M/Z ESI: 1.10 min, 256.18 (M+1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ  
12.58 (br. s, 1H), 8.84 (s, 1H), 8.37 (d, J=6Hz, 1H), 8.02-7.86 (m, 3H), 7.52 (q, J=6Hz,  
9Hz, 1H), 7.26 (s, 1H), 7.02 (b. s, 1H).

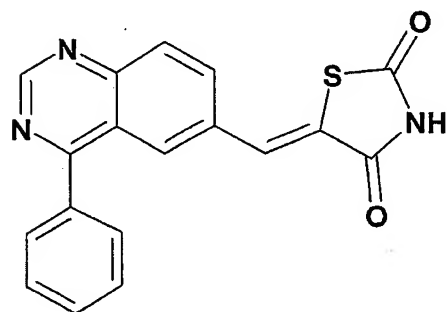
Example 15: 5-(3-Methyl-benzo[d]isoxazol-5-ylmethylene)-thiazolidine-2,4-dione



Following the general method as outlined in Example 1, starting from 3-Methyl-benzo[d]isoxazole-5-carbaldehyde (intermediate 6) and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

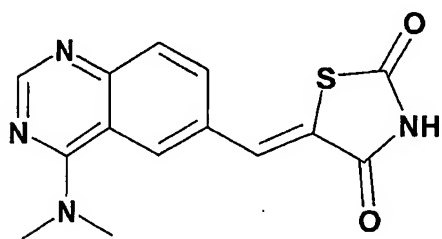
HPLC: 2.99 min. LC-MS: M/Z ESI: 1.30 min, 259.17 (M-1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ  
12.58 (br. s, 1H), 8.08 (s, 1H), 7.95 (s, 1H), 7.85 (s, 2H), 2.59 (s, 3H).

Example 16: 5-(4-Phenyl-quinazolin-6-ylmethylene)-thiazolidine-2,4-dione



Following the general method as outlined in Example 1, starting from 4-Phenyl-quinazoline-6-carbaldehyde (intermediate 13) and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

HPLC: 3.45 min. LC-MS: M/Z ESI: 1.25 min, 334.15 (M+1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ  
12.74 (br. s, 1H), 9.43 (s, 1H), 8.24 (m, 2H), 8.00-7.86 (m, 2H), 7.72-7.66 (m, 5H).

Example 17: 5-(4-Dimethylamino-quinazolin-6-ylmethylene)-thiazolidine-2,4-dione

Following the general method as outlined in Example 1, starting from 4-Dimethylamino-quinazoline-6-carbaldehyde (intermediate 14) and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

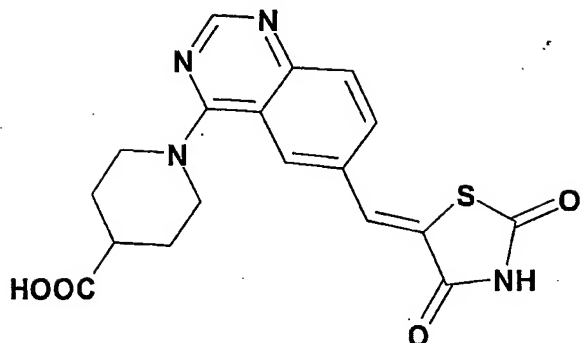
HPLC: 1.47 min. LC-MS: M/Z ESI: 1.26 min, 301.26 (M+1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ 8.81 (s, 1H), 8.54 (s, 1H), 8.16-7.95 (m, 3H), 7.13-7.26 (d, 2H), 3.63 (s, 6H).

The following examples were synthesized as described in Example 1 and 17 starting from intermediates 15 to 31 and 1,3-thiazolidine-2,4-dione

Example	Intermediate# as starting material	Compound name	Mass (M+1)
18	16	5-[(4-aminoquinazolin-6-yl)methylene]-1,3-thiazolidine-2,4-dione	273.29
19	15	5-[(4-piperidin-1-ylquinazolin-6-yl)methylene]-1,3-thiazolidine-2,4-dione	341.40
20	22	5-[(4-morpholin-4-ylquinazolin-6-yl)methylene]-1,3-thiazolidine-2,4-dione	343.20
21	17	5-{{4-(benzylamino)quinazolin-6-yl}methylene}-1,3-thiazolidine-2,4-dione	363.10
22	21	5-{{4-(diethylamino)quinazolin-6-yl}methylene}-1,3-thiazolidine-2,4-dione	329.30
23	18	5-({4-[(pyridin-2-ylmethyl)amino]quinazolin-6-yl}methylene)-1,3-thiazolidine-2,4-dione	364.40

24	19	5-({4-[(pyridin-3-ylmethyl)amino]quinazolin-6-yl}methylene)-1,3-thiazolidine-2,4-dione	364.40
25	23	ethyl 1-{6-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]quinazolin-4-yl}piperidine-3-carboxylate	413.20
26	25	ethyl 1-{6-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]quinazolin-4-yl}piperidine-4-carboxylate	413.30
27	24	tert-butyl 1-{6-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]quinazolin-4-yl}-L-prolinate	427.20
28	20	5-{[4-(4-methylpiperazin-1-yl)quinazolin-6-yl]methylene}-1,3-thiazolidine-2,4-dione	356.13
29	31	5-{[4-(4-pyrimidin-2-ylpiperazin-1-yl)quinazolin-6-yl]methylene}-1,3-thiazolidine-2,4-dione	420.20
30	30	5-({4-[4-(4-fluorophenyl)piperidin-1-yl]quinazolin-6-yl}methylene)-1,3-thiazolidine-2,4-dione	435.30
31	29	5-{[4-(4-benzylpiperidin-1-yl)quinazolin-6-yl]methylene}-1,3-thiazolidine-2,4-dione	431.30
32	28	5-({4-[4-(2-phenylethyl)piperidin-1-yl]quinazolin-6-yl}methylene)-1,3-thiazolidine-2,4-dione	445.40
33	27	5-{[4-(4-methylpiperidin-1-yl)quinazolin-6-yl]methylene}-1,3-thiazolidine-2,4-dione	355.20
34	26	5-{[4-(4-hydroxypiperidin-1-yl)quinazolin-6-yl]methylene}-1,3-thiazolidine-2,4-dione	357.40

Example 35: 1-[6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-quinazolin-4-yl]-piperidine-4-carboxylic acid

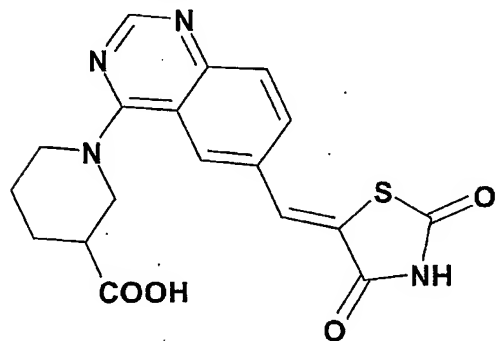


50 mg of Ethyl 1-[6-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]quinazolin-4-yl]piperidine-4-carboxylate (example 26) was dissolved in 2ml solution of THF/water (1/1). A few drops of 5N NaOH were added, and the reaction was stirred for 12h at rt.

5 After completion of the reaction, solvents were evaporated and titled compound was precipitated in diethylether as a yellow solid (40mg, 82%).

HPLC: 1.43 min. LC-MS: M/Z ESI: 1.15 min, 385.20 (M+1).

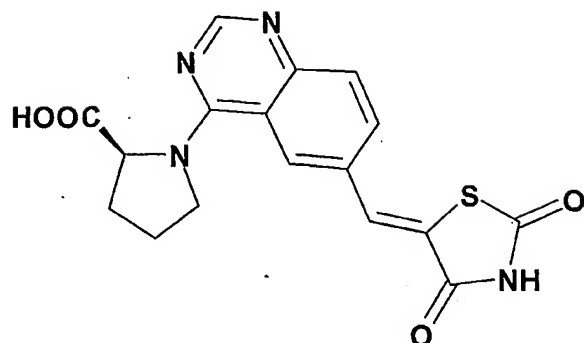
Example 36: 1-[6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-quinazolin-4-yl]-piperidine-3-carboxylic acid



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Following the general method as outlined in Example 35, the title compound was obtained. HPLC: 1.50 min. LC-MS: M/Z ESI: 1.10 min, 385.40 (M+1).

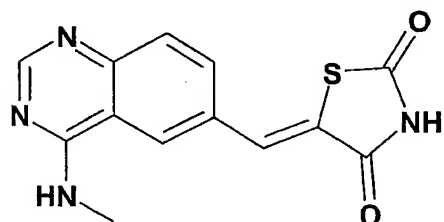
Example 37: 1-[6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-quinazolin-4-yl]-pyrrolidine-2-carboxylic acid



10 mg of tert-butyl 1-{6-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]quinazolin-4-yl}-L-prolinate (example 27) was stirred in a 25% (TFA/DCM) solution for 12h at rt. The solvents were evaporated under vacuo and expected compound was precipitated with diethyl  
 5 ether to give pure 1-[6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-quinazolin-4-yl]-pyrrolidine-2-carboxylic acid (7 mg, 81%).

HPLC: 1.43 min. LC-MS: M/Z ESI: 1.10 min, 371.30 (M+1).

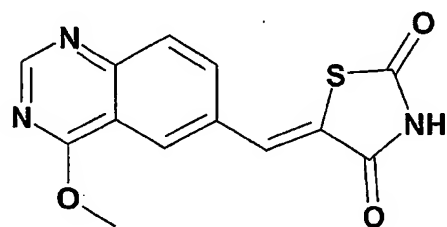
Example 38: 5-(4-Methylamino-quinazolin-6-ylmethylene)-thiazolidine-2,4-dione



10 Following the general method as outlined in Example 1, starting from 4-methylamino-quinazoline-6-carbaldehyde (intermediate 11) and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

HPLC: 1.43 min. LC-MS: M/Z ESI: 1.03 min, 287.19 (M+1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ  
 11.97 (br. s, 1H), 8.53 (br. s, 2H), 8.37 (s, 1H), 7.92 (d, J=8Hz, 1H), 7.76 (s, 2H), 3.03 (s,  
 15 3H)

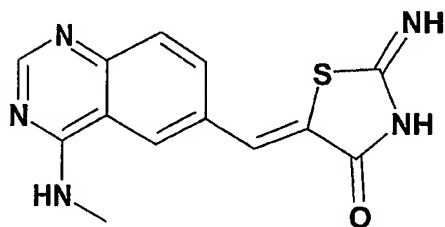
Example 39: 5-(4-Methoxy-quinazolin-6-ylmethylene)-thiazolidine-2,4-dione



Following the general method as outlined in Example 1, starting from 4-methoxy-quinazoline-6-carbaldehyde (intermediate 10) and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

HPLC: 2.57 min. LC-MS: M/Z ESI: 1.12 min, 288.20 (M+1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ  
12.74 (br. s, 1H), 8.86 (s, 1H), 8.32 (s, 1H), 8.11 (m, 1H), 8.03-7.98 (m, 2H), 4.18 (s, 3H)

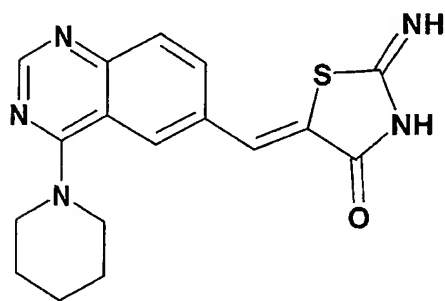
Example 40: 2-Imino-5-(4-methylamino-quinazolin-6-ylmethylene)-thiazolidin-4-one



Following the general method as outlined in Example 1, starting from 4-methylamino-quinazoline-6-carbaldehyde (intermediate 11) and 2-imino-1,3-thiazolidin-4-one, the title compound was obtained.

HPLC: 2.43 min. LC-MS: M/Z ESI: 1.07 min, 286.14 (M+1).

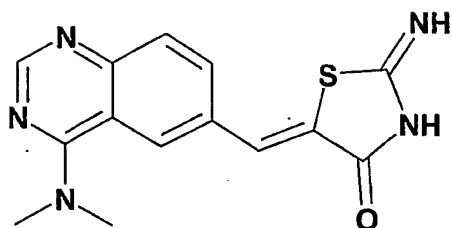
Example 41: 2-Imino-5-(4-piperidine-quinazolin-6-ylmethylene)-thiazolidin-4-one



Following the general method as outlined in Example 1, starting from 4-piperidine-quinazoline-6-carbaldehyde (intermediate 72) and 2-imino-1,3-thiazolidin-4-one, the title compound was obtained.

HPLC: 1.78 min. LC-MS: M/Z ESI: 1.40 min, 340.26 (M+1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ  
8.76 (s, 1H), 8.18 (s, 1H), 8.16 (d, J=6Hz, 1H), 7.88 (d, J=9Hz, 1H), 7.80 (s, 1H), 4.09 (s, 4H), 1.80 (s, 6H).

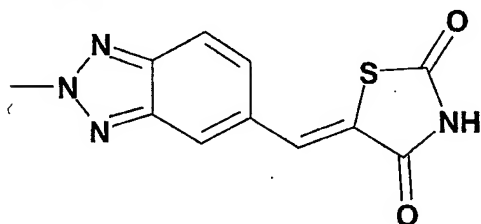
Example 42: 2-Imino-5-(4-dimethylamino-quinazolin-6-ylmethylene)-thiazolidin-4-one



Following the general method as outlined in Example 1, starting from 4-piperidine-quinazoline-6-carbaldehyde (intermediate 14) and 2-imino-1,3-thiazolidin-4-one, the title compound was obtained.

- 5 HPLC: 1.32 min. LC-MS(10 min.): M/Z ESI: 1.54 min, 300.23 (M+1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ 8.82 (s, 1H), 8.53 (s, 1H), 8.16 (d, J=9Hz, 1H), 7.87 (t, J=9Hz, 2H), 3.65 (s, 6H).

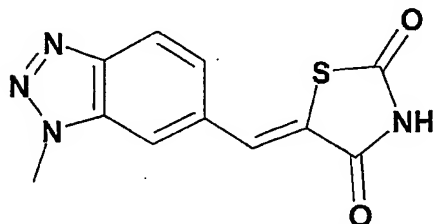
Example 43: 5-(2-Methyl-2H-benzotriazol-5-ylmethylene)-thiazolidine-2,4-dione



- 10 Following the general method as outlined in Example 1, starting from 2-Methyl-2H-benzotriazole-5-carbaldehyde (intermediate 33) and thiazolidindione, the title compound was obtained.

HPLC: 2.68 min. <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ 12.58 (br. s, 1H), 7.98 (s, 1H), 7.92 (d, J=9Hz, 1H), 7.62 (d, J=6Hz, 1H), 7.43 (s, 1H), 4.48 (s, 3H).

Example 44: 5-(3-Methyl-3H-benzotriazol-5-ylmethylene)-thiazolidine-2,4-dione

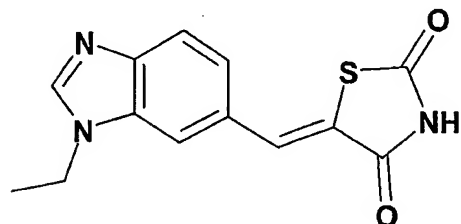


- 15 Following the general method as outlined in Example 1, starting from 3-Methyl-3H-benzotriazole-5-carbaldehyde (intermediate 34) and thiazolidindione, the title compound was obtained.



HPLC: 2.35 min. LC-MS: M/Z ESI: 1.22 min, 259.23 (M-1).  $^1\text{H}$  NMR: (DMSO- $d_6$ )  $\delta$  12.58 (br. s, 1H), 8.17 (d,  $J=9\text{Hz}$ , 1H), 8.07 (s, 1H), 7.62 (d,  $J=6\text{Hz}$ , 1H), 7.47 (s, 1H), 4.33 (s, 3H).

Example 45: 5-(3-Ethyl-3H-benzimidazol-5-ylmethylene)-thiazolidine-2,4-dione



5-(4-Amino-3-ethylamino-benzylidene)-thiazolidine-2,4-dione (50mg, 0.19mmol) (intermediate 36) was dissolved in formic acid (5mL) and the solution stirred at 100°C overnight. Formic acid was then removed *in vacuo*. The crude residue was then purified by silica gel column to give the title compound (35mg, 63%).

HPLC: 1.71 min. LC-MS: M/Z ESI: 0.82 min, 274.21 (M+1).

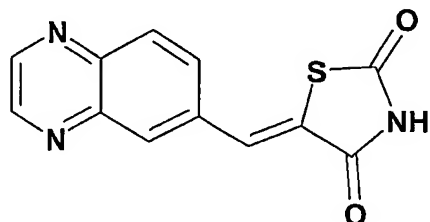
The following examples were synthesized as described in Example 45 starting from intermediates 37 to 54 and 1,3-thiazolidine-2,4-dione.

Example	Intermediate# as starting material	Compound name	Mass (M+1)
46	37	5-{{1-(4-phenylbutyl)-1H-benzimidazol-6-yl}methylene}-1,3-thiazolidine-2,4-dione	378.30
47	50	5-[(1-prop-2-yn-1-yl-1H-benzimidazol-6-yl)methylene]-1,3-thiazolidine-2,4-dione	284.24
48	38	5-[(1-{2-[4-(trifluoromethyl)phenyl]ethyl}-1H-benzimidazol-6-yl)methylene]-1,3-thiazolidine-2,4-dione	418.17
49	39	5-({1-[2-(4-hydroxyphenyl)ethyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione	366.26

50	40	methyl 4-{6-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1H-benzimidazol-1-yl}cyclohexanecarboxylate	386.35
51	41	5-({1-[2-(5-methoxy-1H-indol-3-yl)ethyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione	419.21
52	42	5-({1-[(1-methyl-1H-pyrazol-4-yl)methyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione	340.99
53	43	5-({1-[2-(3,4-dimethoxyphenyl)ethyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione	410.37
54	54	5-({1-[2-(4-phenoxyphenyl)ethyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione	442.51
55	44	5-({1-[4-(trifluoromethyl)benzyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione	404.16
56	45	4-{6-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1H-benzimidazol-1-yl}cyclohexanecarboxylic acid	372.18
57	46	5-[(1-isobutyl-1H-benzimidazol-6-yl)methylene]-1,3-thiazolidine-2,4-dione	302.25
58	47	5-({1-[2-(1,3-benzodioxol-4-yl)ethyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione	394.27
59	48	5-({1-[2-(2-phenoxyphenyl)ethyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione	442.29
60	49	5-[[1-(3,3-diphenylpropyl)-1H-benzimidazol-6-yl]methylene]-1,3-thiazolidine-2,4-dione	440.27

61	51	5-{[1-(2-methoxybenzyl)-1H-benzimidazol-6-yl]methylene}-1,3-thiazolidine-2,4-dione	366.33
62	52	5-{[1-(3-furylmethyl)-1H-benzimidazol-6-yl]methylene}-1,3-thiazolidine-2,4-dione	326.24
63	53	5-[(1-propyl-1H-benzimidazol-6-yl)methylene]-1,3-thiazolidine-2,4-dione	288.18

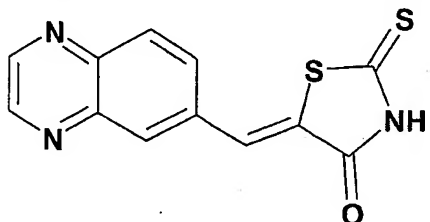
Example 64: 5-Quinoxalin-6-ylmethylene-thiazolidine-2,4-dione



Following the general method as outlined in Example 1, starting from quinoxaline-6-carbaldehyde (intermediate 55) and thiazolidindione, the title compound was obtained.

- 5 HPLC: 2.48 min. LC-MS: M/Z ESI: 1.01 min, 256.20 (M-1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ 12.58 (br. s, 1H), 8.93 (d, J=9Hz, 2H), 8.18 (s, 1H), 8.10 (d, J=9Hz, 1H), 8.03 (d, J=9Hz, 1H), 7.51 (s, 1H).

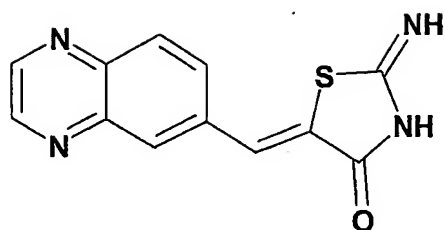
Example 65: 5-Quinoxalin-6-ylmethylene-2-thioxo-thiazolidin-4-one



- 10 Following the general method as outlined in Example 1, starting from quinoxaline-6-carbaldehyde (intermediate 55) and rhodanine, the title compound was obtained.

HPLC: 3.10 min. LC-MS: M/Z ESI: 1.17 min, 272.13 (M-1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ 12.00 (br. s, 1H), 9.02 (s, 2H), 8.31 (s, 1H), 8.21 (d, J=9Hz, 1H), 8.04 (d, J=9Hz, 1H), 7.90 (s, 1H)

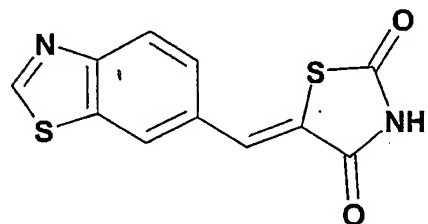
- 15 Example 66: 2-Imino-5-quinoxalin-6-ylmethylene-thiazolidin-4-one



Following the general method as outlined in Example 1, starting from quinoxaline-6-carbaldehyde (intermediate 55) and 2-imino-1,3-thiazolidin-4-one, the title compound was obtained.

5 HPLC: 1.97 min. LC-MS: M/Z ESI: 1.02 min, 255.19 (M-1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ 9.57-9.30 (b. d, J=81Hz, 2H), 9.00 (s, 2H), 8.26-8.07 (m, 3H), 7.84 (s, 1H).

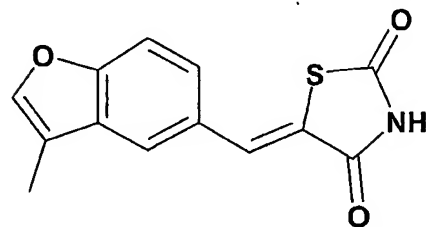
Example 67: 5-Benzothiazol-6-ylmethylene-thiazolidine-2,4-dione



Following the general method as outlined in Example 1, starting from quinoxaline-6-carbaldehyde (intermediate 56) and thiazolidindione, the title compound was obtained.

10 HPLC: 2.85 min. LC-MS: M/Z ESI: 1.06 min, 261.11 (M-1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ 12.58 (br. s, 1H), 9.39 (s, 1H), 8.27 (s, 1H), 8.11 (d, J=9Hz, 1H), 7.70 (d, J=9Hz, 1H), 7.42 (s, 1H).

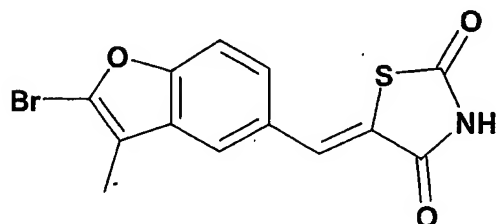
Example 68: 5-(3-Methyl-benzofuran-5-ylmethylene)-thiazolidine-2,4-dione



15 Following the general method as outlined in Example 1, starting from 3-Methyl-benzofuran-5-carbaldehyde (intermediate 57) and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

HPLC: 1.47 min. LC-MS: M/Z ESI: 1.15 min, 257.21 (M-1).  $^1\text{H}$  NMR: (DMSO- $d_6$ )  $\delta$  12.50 (br. s, 1H), 8.87 (d,  $J=6\text{Hz}$ , 1H), 8.38 (d,  $J=9\text{Hz}$ , 1H), 8.07 (t,  $J=12\text{Hz}$ , 2H), 7.92 (d,  $J=9\text{Hz}$ , 1H), 7.53 (q,  $J=6\text{Hz}$ , 12Hz, 1H), 7.45 (s, 1H).

Example 69: 5-(2-Bromo-3-methyl-benzofuran-5-ylmethylene)-thiazolidine-2,4-dione



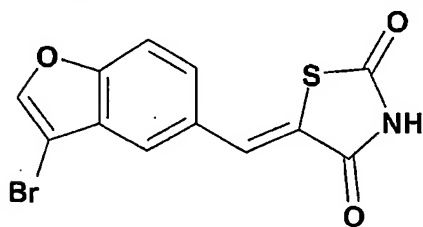
5

In a 25 ml 3 neck flask was placed 5-(3-methyl-benzofuran-5-ylmethylene)-thiazolidine-2,4-dione (100mg, 0.39mmol) (example 68) and  $\text{Br}_2$  (20  $\mu\text{l}$ , 1eq.) in 2 ml of AcOH at  $0^\circ\text{C}$ . The mixture was allowed to warm to room temperature. After 2h at room temperature another equivalent of  $\text{Br}_2$  was added. After 3h the reaction was filtered off to obtain a yellow product being the title compound (87mg, 66%).

10

LC-MS: M/Z ESI: 1.69 min, 339.8 (M+1).  $^1\text{H}$  NMR: (DMSO- $d_6$ )  $\delta$  12.50 (br. s, 1H), 7.93 (s, 1H), 7.82 (s, 1H), 7.72 (d,  $J=6\text{Hz}$ , 1H), 7.54 (d,  $J=6\text{Hz}$ , 1H), 2.20 (s, 3H).

Example 70: 5-(3-bromo-benzofuran-5-ylmethylene)-thiazolidine-2,4-dione



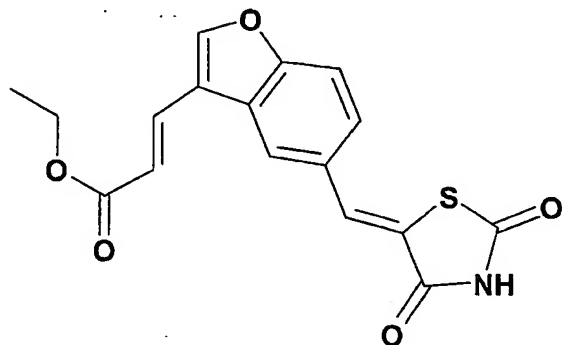
15

Following the general method as outlined in Example 1, starting from 3-Bromo-benzofuran-5-carbaldehyde (intermediate 58) and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

HPLC: 3.92 min. LC-MS: M/Z ESI: 1.57 min, 325.17 (M+1).  $^1\text{H}$  NMR: (DMSO- $d_6$ )  $\delta$  12.60 (br. s, 1H), 8.42 (s, 1H), 8.00 (s, 1H), 7.85 (d,  $J=23\text{Hz}$ , 1H), 7.76 (s, 1H), 7.63 (d,  $J=23\text{Hz}$ , 1H).

20

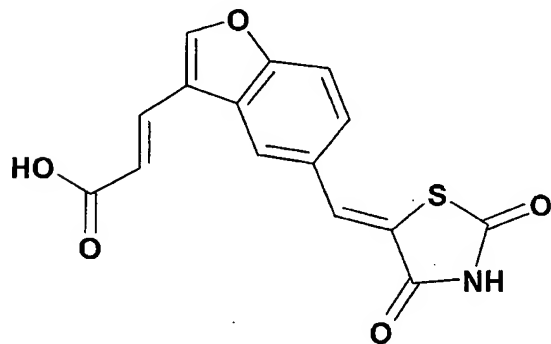
Example 71: 3-[5-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-benzofuran-3-yl]-acrylic acid ethyl ester



Following the general method as outlined in Example 1, starting from 3-(5-Formyl-  
5 benzofuran-3-yl)-acrylic acid ethyl ester (intermediate 60) and 1,3-thiazolidine-2,4-dione,  
the title compound was obtained.

HPLC: 4.00min. LC-MS: M/Z ESI: 1.60 min, 342.20 (M-1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ  
12.50 (br. s, 1H), 8.63 (s, 1H), 8.42 (s, 1H), 8.08 (s, 1H), 7.83 (m, 2H), 7.62 (s, 1H), 4.22  
(q, J=6Hz, 9Hz, 2H), 1.28 (t, J=9Hz, 3H).

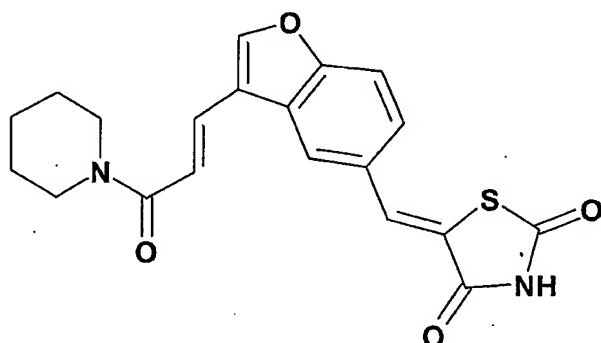
Example 72: 3-[5-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-benzofuran-3-yl]-acrylic acid



3-[5-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-benzofuran-3-yl]-acrylic acid ethyl ester  
(205mg, 0.6mmol) (example 71) were dissolved in THF/water 4:2. To this solution was  
added under stirring 81mg (4eq.) of LiOH.H<sub>2</sub>O. The reaction was stirred for 15h. The  
15 solvents were evaporated, and the residue was precipitated with ether. The solid was  
washed with 1NHCl and dried to afford 170mg (90%) of pure 3-[5-(2,4-Dioxo-thiazolidin-  
5-ylidenemethyl)-benzofuran-3-yl]-acrylic acid.

HPLC: 3.25 min. LC-MS: M/Z ESI: 1.01 min, 314.11 (M-1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ 8.22 (s, 1H), 8.03 (s, 1H), 7.58 (dd, J=9Hz, 33Hz, 2H), 7.43 (s, 1H), 7.25 (d, J=18 Hz, 1H), 7.07 (s, 1H).

Example 73: 5-[3-(3-Oxo-3-piperidin-1-yl-propenyl)-benzofuran-5-ylmethylene]-thiazolidine-2,4-dione



180 mg (0.57mmol) of 3-[5-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-benzofuran-3-yl]-acrylic acid (example 72) was suspended in THF (25ml). To this suspension was added DIEA (2eq.) and piperidine (3eq.). Under stirring was added PyBOP (1.5 eq.). After 30min the reaction mixture became clear, after an additional 1h a precipitate was formed. The reaction was stirred overnight. The precipitate was filtered off and washed with THF and 1N HCl affording the title compound in high purity.

HPLC: 3.91 min. LC-MS: M/Z ESI: 1.58 min, 383.22 (M+1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ 8.46 (s, 1H), 8.19 (s, 1H), 7.71-7.51 (m, 4H), 7.23 (d, J=15Hz, 1H), 3.73 (d, J=48Hz, 2H), 1.51 (d, J=36Hz, 3H).

The following amides were synthesized according to the synthesis of example 73.

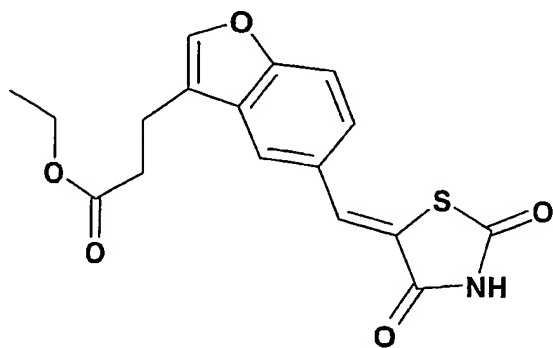
Example	Amine as starting material	Compound name	Mass (M+1)
74	Proline-methylester	Methyl 1-((3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}prop-2-enoyl)prolinate	427.15
75	D-proline-methylester	Methyl 1-((3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}prop-2-	413.15

	methylester	ylidene)methyl]-1-benzofuran-3-yl}prop-2-enoyl)-D-prolinate	
76	Pyrollidine	(5-({3-[(3-oxo-3-pyrrolidin-1-ylprop-1-en-1-yl]-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione	369.52
77	Morpholine	5-({3-[3-morpholin-4-yl-3-oxoprop-1-en-1-yl]-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione	385.07
78	L-proline-methylester	Methyl 1-(3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}prop-2-enoyl)-L-prolinate	427.13
79	N-methyl-cyclohexylamine	N-cyclohexyl-3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}-N-methylacrylamide	411.12
80	N-ethyl-hydroxyethyl-amine	3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}-N-ethyl-N-(2-hydroxyethyl)acrylamide	387.10
81	Cyclobutylamine	N-cyclobutyl-3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}acrylamide	369.13
82	Azetidine	5-({3-[3-azetidin-1-yl-3-oxoprop-1-en-1-yl]-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione	355.64
83	1,3-dihydro-2H-isoindole	5-({3-[3-(1,3-dihydro-2H-isoindol-2-yl)-3-oxoprop-1-en-1-yl]-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione	415.00 (M-1)
84	Azepan	5-({3-[3-azepan-1-yl-3-oxoprop-1-en-1-yl]-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione	397.46



85	Piperidin-1-ylamine	3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}-N-piperidin-1-ylacrylamide	398.00
86	Pyridin-3-yl-methylamine	3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}-N-(pyridin-3-ylmethyl)acrylamide	406.10
87	Cyclohexylamine	N-cyclohexyl-3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}acrylamide	397.08
88	4-N-methyl-piperazine	5-({3-[3-(4-methylpiperazin-1-yl)-3-oxoprop-1-en-1-yl]-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione	398.02
89	Cycloheptylamine	N-cycloheptyl-3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}acrylamide	411.44
90	Pyroline	5-({3-[3-(2,5-dihydro-1H-pyrrol-1-yl)-3-oxoprop-1-en-1-yl]-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione	367.11
91	Cyclopentylamine	N-cyclopentyl-3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}acrylamide	383.11

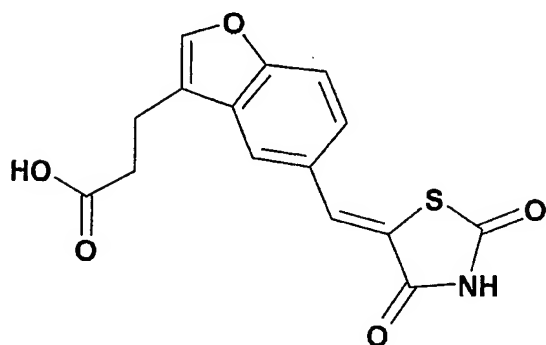
Example 92: 3-[5-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-benzofuran-3-yl]-propionic acid ethyl ester



Following the general method as outlined in Example 1, starting from 3-(5-Formyl-benzofuran-3-yl)-propionic acid ethylester (intermediate 71) and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

HPLC: 3.94mn. LC-MS: M/Z ESI: 2.87min, 346.15 (M+1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ 12.58 (br. s, 1H), 7.92 (d, J=6Hz, 3H), 7.72 (d, J=9Hz, 1H), 7.53 (d, J=9Hz, 1H), 4.03 (q, J=9Hz, 15Hz, 2H), 2.94 (t, J=9Hz, 2H), 2.73 (t, J=6Hz, 2H), 1.14 (t, J=6Hz).

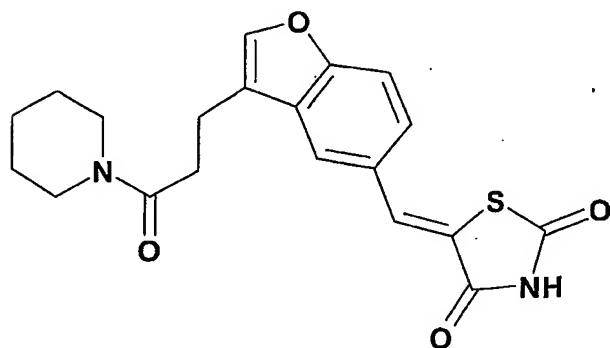
Example 93: 3-[5-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-benzofuran-3-yl]-propionic acid



The title compound was obtained applying standard saponifications techniques as described for example 72 using example 92 as starting material.

HPLC: 3.09 min. LC-MS(10 min.): M/Z ESI: 1.19min, 316.14 (M-1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ 12.58 (br. s, 1H), 12.22 (b. s, 1H), 7.93 (d, J=12Hz, 3H), 7.70 (d, J=9Hz, 1H), 7.54 (d, J=9Hz, 1H), 2.91 (t, J=9Hz, 2H), 2.65 (t, 6Hz, 2H).

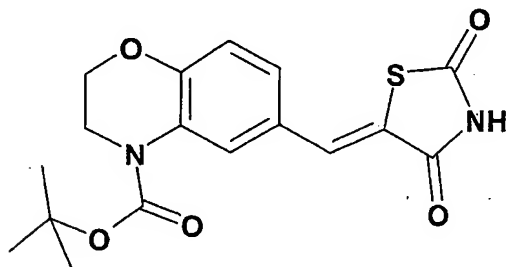
Example 94: 5-[3-(3-Oxo-3-piperidin-1-yl-propyl)-benzofuran-5-ylmethylene]-thiazolidine-2,4-dione



The title compound was obtained applying the synthetic protocol as described for example 73 using example 93 as starting material.

HPLC: 3.783 min. LC-MS: M/Z ESI: 1.46 min, 385.14 (M+1).  $^1\text{H}$  NMR: (DMSO- $d_6$ )  $\delta$  12.66 (br. s, 1H), 8.06 (s, 3H), 8.01 (s, 1H), 7.79 (s, 1H), 3.50-1.60 (m, 14H).

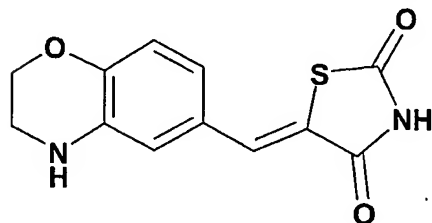
5 Example 95: 6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-2,3-dihydro-benzo[1,4]oxazine-4-carboxylic acid tert-butyl ester



Following the general method as outlined in Example 1, starting from 6-Formyl-2,3-dihydro-benzo[1,4]oxazine-4-carboxylic acid tert-butyl ester (intermediate 62) and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

HPLC: 2.52 min. LC-MS: M/Z ESI: min, 261.21 (M-Boc+1).

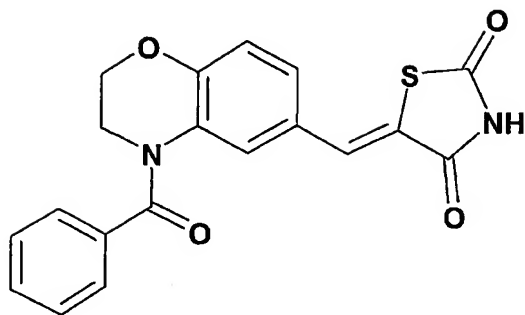
Example 96: 5-(3,4-Dihydro-2H-benzo[1,4]oxazin-6-ylmethylene)-thiazolidine-2,4-dione



100mg of 6-Formyl-2,3-dihydro-benzo[1,4]oxazine-4-carboxylic acid tert-butyl ester (intermediate 62) were treated with TFA/DCM 25% for 2h. The solvents were evaporated to dryness and the remaining crude was used for the Knoevenagel reaction as outlined in Example 1 without further purification to obtain the title compound as yellow solid.

HPLC: 2.56 min. LC-MS: M/Z ESI: 1.14 min, 261.24 (M-1).  $^1\text{H}$  NMR: (DMSO- $d_6$ )  $\delta$  12.58 (br. s, 1H), 7.57 (s, 1H), 6.78 (s, 3H), 4.17 (t,  $J=3\text{Hz}$ , 2H), 3.28 (t,  $J=6\text{Hz}$ , 2H).

20 Example 97: 5-(4-Benzoyl-3,4-dihydro-2H-benzo[1,4]oxazin-6-ylmethylene)-thiazolidine-2,4-dione

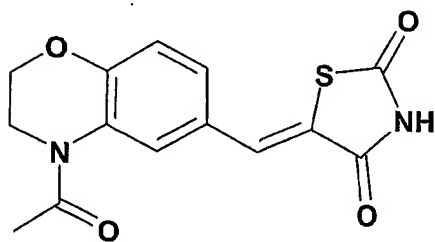


5-(3,4-Dihydro-2H-benzo[1,4]oxazin-6-ylmethylene)-thiazolidine-2,4-dione (example 96) (35mg, 0.13mmol) in 4ml anhydrous THF were treated with benzoylchloride (156uL, 10eq.) in the presence of DIEA (2eq.) for 3h. Excess of benzoylchloride was hydrolysed, EtOAc was added and the organic phase was washed with NaHCO<sub>3</sub> and brine. The crude was purified on silica gel using EtOAc/cyclohexane 3:7 as eluent affording 14mg (35%) of the title compound.

HPLC: 4.57 min. LC-MS: M/Z ESI: 2.11 min, 364.91 (M-1).

The following example was synthesized in the same way as described for example 97.

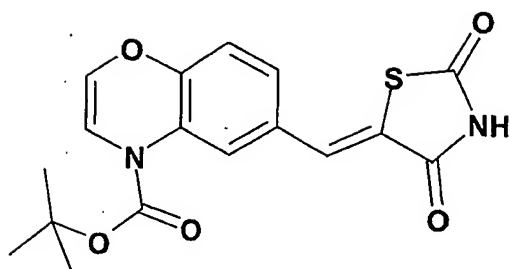
10 Example 98: 5-(4-Acetyl-3,4-dihydro-2H-benzo[1,4]oxazin-6-ylmethylene)-thiazolidine-2,4-dione



Yield = 43mg (95%)

HPLC: 2.65 min. LC-MS: M/Z ESI: 1.12 min, 305.24 (M+1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ 12.58 (br. s, 1H), 8.30 (b s, 1H), 7.71 (s, 1H), 7.35 (d, J=9Hz, 1H), 7.05 (d, J=9Hz, 1H), 4.33 (t, J=6Hz, 2H), 4.00 (t, J=6Hz, 2H).

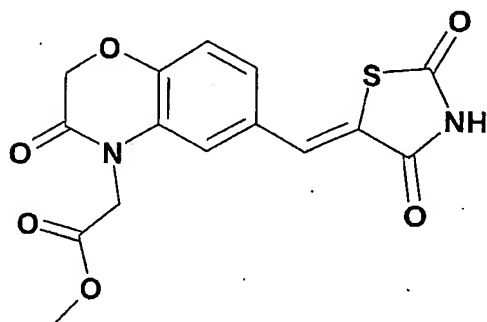
Example 99: 6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-benzo[1,4]oxazine-4-carboxylic acid tert-butyl ester



Following the general method as outlined in Example 1, starting from 6-Formyl-benzo[1,4]oxazine-4-carboxylic acid tert-butyl ester (intermediate 63) and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

- 5 HPLC: 4.23 min. LC-MS: M/Z ESI: 1.82 min, 359.16 (M-1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ 12.50 (br. s, 1H), 7.63 (d, J=3Hz, 2H), 7.31 (d, J=3Hz, 1H), 6.95 (d, J=6Hz, 1H), 6.30 (s, 2H).

Example 100: [6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-3-oxo-2,3-dihydro-benzo[1,4]-oxazin-4-yl]-acetic acid methyl ester



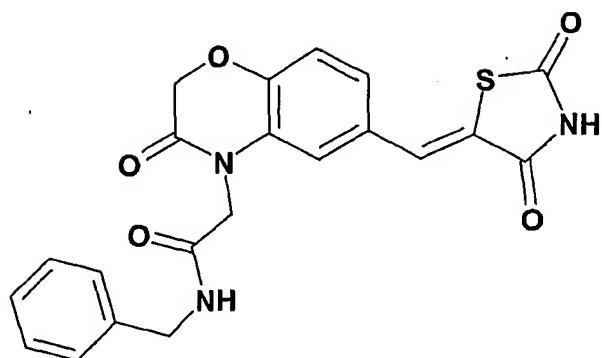
10

Following the general method as outlined in Example 1, starting from (6-Formyl-3-oxo-2,3-dihydro-benzo[1,4]oxazin-4-yl)-acetic acid methyl ester (intermediate 64) and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

- HPLC: 2.83 min. LC-MS: M/Z ESI: 1.20 min, 347.25 (M-1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ 12.58 (br. s, 1H), 7.76 (s, 1H), 7.36 (s, 1H), 7.20 (m, 2H), 4.82 (d, J=15Hz, 4H), 3.71 (s, 3H).

15

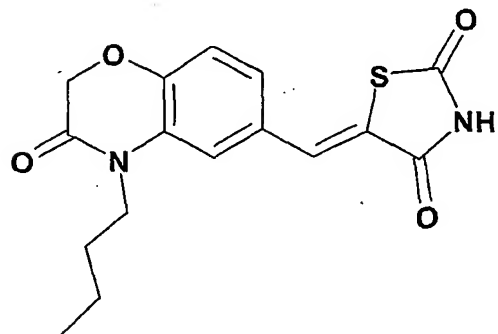
Example 101: N-Benzyl-2-[6-(2,4-dioxo-thiazolidin-5-ylidenemethyl)-3-oxo-2,3-dihydro-benzo[1,4]oxazin-4-yl]-acetamide



[6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-3-oxo-2,3-dihydro-benzo[1,4]-oxazin-4-yl]-acetic acid methyl ester (195mg, 0.56mmol) (example 100) were saponified using 2 eq. of LiOH as described for example 74 affording [6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-3-oxo-2,3-dihydro-benzo[1,4]oxazin-4-yl]-acetic acid. The so obtained acid (50mg, 0.15mmol) was dissolved in THF. HOBt (32mg, 1.5eq.), EDC (43mg, 1.5eq.) and benzylamine (25mg, 1.5 eq.) were added while stirring. The reaction mixture was stirred for 15h at rt. EtOAc was added and the organic phase was washed with 1N HCl, NaHCO<sub>3</sub>, brine each of which three times. The crude residue after evaporating the solvents was purified on silica gel using DCM/EtOAc as eluents to give the title compound as colourless powder (35mg, 54%).

HPLC: 3.06 min. LC-MS: M/Z ESI: 1.27 min, 424.21 (M+1).

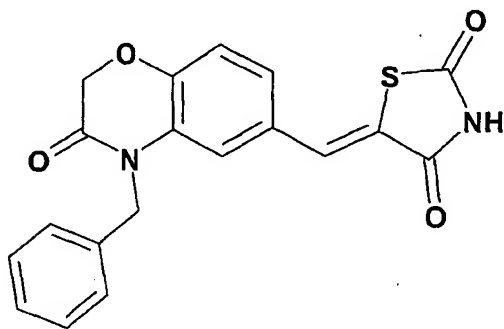
Example 102: 5-(4-Butyl-3-oxo-3,4-dihydro-2H-benzo[1,4]oxazin-6-ylmethylene)-thiazolidine-2,4-dione



Following the general method as outlined in Example 1, starting from 4-Butyl-3-oxo-3,4-dihydro-2H-benzo[1,4]oxazine-6-carbaldehyde (intermediate 65) and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

HPLC: 3.67 min. LC-MS: M/Z ESI: 1.49 min, 331.23 (M-1).  $^1\text{H}$  NMR: (DMSO- $d_6$ )  $\delta$  12.58 (br. s, 1H), 7.85 (s, 1H), 7.43 (s, 1H), 7.24 (d,  $J=6\text{Hz}$ , 1H), 7.15 (d,  $J=9\text{Hz}$ , 1H), 4.73 (s, 2H), 3.91 (t,  $J=3\text{Hz}$ , 2H), 1.57, (m, 2H), 1.36 (m, 2H), 0.91 (t,  $J=9\text{Hz}$ , 3H).

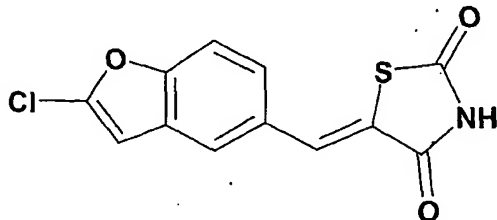
5 Example 103: 5-(4-Benzyl-3-oxo-3,4-dihydro-2H-benzo[1,4]oxazin-6-ylmethylene)-thiazolidine-2,4-dione



Following the general method as outlined in Example 1, starting from 4-Benzyl-3-oxo-3,4-dihydro-2H-benzo[1,4]oxazine-6-carbaldehyde (intermediate 66) and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

10 HPLC: 3.67 min. LC-MS: M/Z ESI: 1.46 min, 365.17 (M-1).  $^1\text{H}$  NMR: (DMSO- $d_6$ )  $\delta$  12.58 (br. s, 1H), 7.68 (s, 1H), 7.38-7.22 (m, 8H), 5.24 (s, 2H), 4.97 (s, 2H).

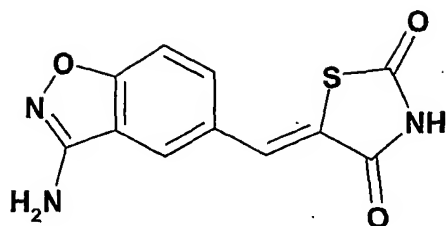
Example 104: 5-(2-Chloro-benzofuran-5-ylmethylene)-thiazolidine-2,4-dione



15 Following the general method as outlined in Example 1, starting from 2-Chloro-5-[1,3]dioxolan-2-yl-benzofurane (intermediate 67) and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

HPLC: 3.84 min. LC-MS: M/Z ESI: 1.62 min, 278.12 (M-1).  $^1\text{H}$  NMR: (DMSO- $d_6$ )  $\delta$  7.90-7.75 (M, 2H), 7.68 (d,  $J=9\text{Hz}$ , 1H), 7.52 (d,  $J=9\text{Hz}$ , 1H), 7.09 (s, 1H).

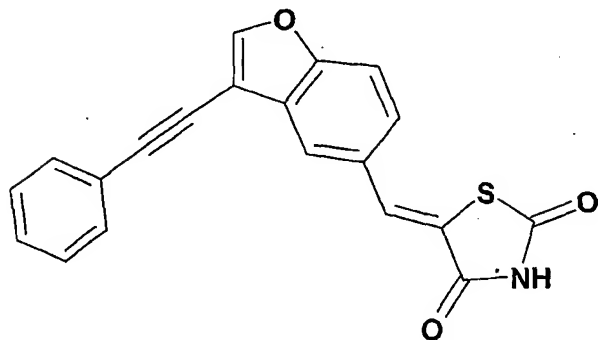
Example 105: 5-(3-Amino-benzo[d]isoxazol-5-ylmethylene)-thiazolidine-2,4-dione



Following the general method as outlined in Example 1, starting from 3-Amino-benzofuran-5-carbaldehyde (intermediate 68) and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

5 HPLC: 2.45 min. LC-MS: M/Z ESI: 0.97 min, 260.17 (M-1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ 12.60 (br. s, 1H), 8.01 (s, 1H), 7.85 (s, 1H), 7.60 (d, J=9Hz, 1H), 6.67 (s, 1H).

Example 106: 5-(3-Phenylethynyl-benzofuran-5-ylmethylene)-thiazolidine-2,4-dione



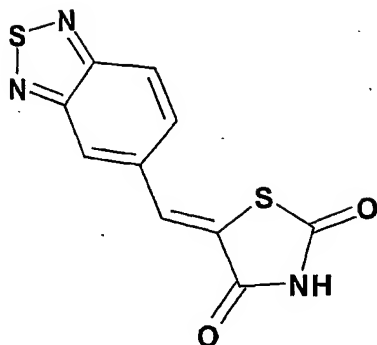
10 Following the general method as outlined in Example 1, starting from 3-Phenylethynyl-benzofuran-5-carbaldehyde (intermediate 59) and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

HPLC: 4.82 min. LC-MS: M/Z ESI: 2.02 min, 344.18 (M-1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ 12.58 (br. s, 1H), 8.49 (s, 1H), 7.92 (s, 1H), 7.72 (d, J=9Hz, 1H), 7.62 (m, 3H), 7.45 (m, 4H).

15

Example 107: 5-Benzo[1,2,5]thiadiazol-5-ylmethylene-thiazolidine-2,4-dione

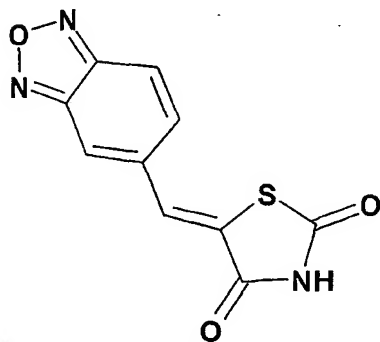




Following the general method as outlined in Example 1, starting from 2,1,3-Benzothiadiazole-5-carbaldehyde and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

- 5 HPLC: 3.03 min. LC-MS: M/Z ESI: 1.14 min, 262.11 (M-1).  $^1\text{H}$  NMR: (DMSO- $d_6$ )  $\delta$  12.58 (br. s, 1H), 8.11 (m, 2H), 7.90 (d,  $J=9\text{Hz}$ , 1H), 7.47 (s, 1H).

Example 108: 5-Benzo[1,2,5]oxadiazol-5-ylmethylene-thiazolidine-2,4-dione

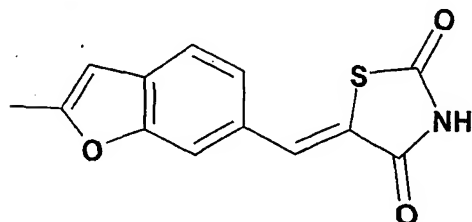


Following the general method as outlined in Example 1, starting from 2,1,3-

- 10 Benzoxadiazole-5-carbaldehyde and 1,3-thiazolidine-2,4-dione, the title compound was obtained.

HPLC: 3.02 min. LC-MS: M/Z ESI: 1.17 min, 246.17 (M-1).  $^1\text{H}$  NMR: (DMSO- $d_6$ )  $\delta$  12.58 (br. s, 1H), 8.07 (m, 2H), 7.82 (d,  $J=9\text{Hz}$ , 1H), 7.40 (s, 1H).

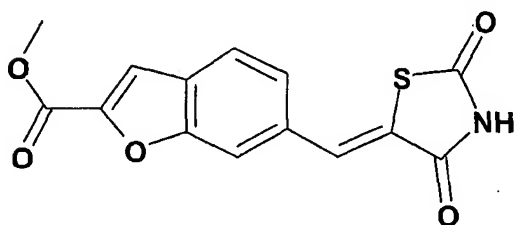
Example 109: 5-(2-Methyl-benzofuran-6-ylmethylene)-thiazolidine-2,4-dione



Following the general method as outlined in Example 1, starting from 2-Methyl-5-[1,3]dioxolan-2-yl-benzofuran (intermediate 72) and 1,3-thiazolidine-2,4-dione, the title compound was obtained after purification on reverse phase HPLC (solvents gradient H<sub>2</sub>O/CH<sub>3</sub>CN 0.1% TFA).

- 5 HPLC: 3.65 min, 90.75%. LC-MS: M/Z ESI: 1.65 min, 258.21 (M-1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ 12.45 (sl, 1H), 7.88 (s, 1H), 7.77 (d, 1H, J=1.5 Hz), 7.64 (d, 1H, J=8.6 Hz), 7.47 (dd, 1H, J=8.6, 1.5 Hz), 6.69 (s, 1H), 2.37 (s, 3H).

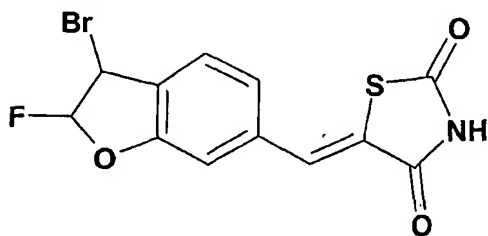
Example 110: 5-(2-Carboxymethyl-benzofuran-6-ylmethylene)-thiazolidine-2,4-dione



- 10 Following the general method as outlined in Example 1, starting from 5-[1,3]Dioxolan-2-yl-benzofuran-2-carboxylic acid methyl ester (intermediate 73) and 1,3-thiazolidine-2,4-dione, the title compound was obtained after purification on reverse phase HPLC (solvents gradient H<sub>2</sub>O/CH<sub>3</sub>CN 0.1% TFA).

- 15 HPLC: 3.32 min, 92.06%. LC-MS: M/Z ESI: 1.51 min, 302.19 (M-1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ 12.52 (sl, 1H), 7.97 (d, 1H, J=1.5 Hz), 7.82 (m, 3H), 7.69 (dd, 1H, J=8.6, 1.5 Hz), 3.90 (s, 3H).

Example 111: 5-(3-Bromo-2-fluoro-2,3-dihydro-benzofuran-6-ylmethylene)-thiazolidine-2,4-dione

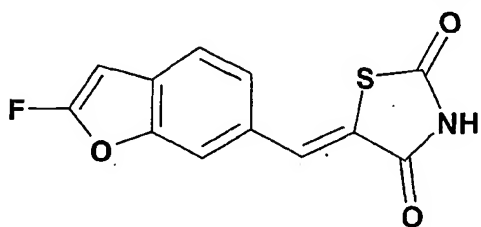


- 20 Following the general method as outlined in Example 1, starting from 3-Bromo-2-fluoro-benzofuran-5-carbaldehyde (intermediate 74) and 1,3-thiazolidine-2,4-dione, the title

compound was obtained after purification on reverse phase HPLC (solvents gradient H<sub>2</sub>O/CH<sub>3</sub>CN 0.1% TFA).

HPLC: 3.66 min, 92.37%. LC-MS: M/Z ESI: 1.56 min, 343.09 (M-1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ 12.82 (sl, 1H), 8.00 (d, 1H, J=1.8 Hz), 7.88 (dd, 1H, J=8.5, 1.8 Hz), 7.55 (d, 1H, J=8.5 Hz), 7.03 (d, 1H, <sup>2</sup>J<sub>H-F</sub>=59.5 Hz), 6.20 (d, 1H, <sup>3</sup>J<sub>H-F</sub>=15.3 Hz). <sup>19</sup>F NMR: (DMSO-d<sub>6</sub>) δ -114.66.

Example 112: 5-(2-Fluoro-benzofuran-6-ylmethylene)-thiazolidine-2,4-dione



Following the general method as outlined in Example 1, starting from 2-Fluoro-5-[1,3]dioxolan-2-yl-benzofuran (intermediate 75) and 1,3-thiazolidine-2,4-dione, the title compound was obtained after purification on reverse phase HPLC (solvents gradient H<sub>2</sub>O/CH<sub>3</sub>CN 0.1% TFA).

HPLC: 3.67 min, 99.47%. LC-MS: M/Z ESI: 1.51 min, 262.14 (M-1). <sup>1</sup>H NMR: (DMSO-d<sub>6</sub>) δ 12.04 (sl, 1H), 7.89 (d, 1H, J=1.5 Hz), 7.83 (d, 1H, J=1.5 Hz), 7.73 (d, 1H, J=8.6 Hz), 7.55 (dd, 1H, J=8.6, 1.5 Hz), 6.47 (d, 1H, <sup>3</sup>J<sub>H-F</sub>=6.4 Hz). <sup>19</sup>F NMR: (DMSO-d<sub>6</sub>) δ -111.28, -112.18.

Example 113 : Preparation of a pharmaceutical formulation

The following formulation examples illustrate representative pharmaceutical compositions according to the present invention being not restricted thereto.

Formulation 1 – Tablets

A compound of formula (I) is admixed as a dry powder with a dry gelatin binder in an approximate 1:2 weight ration. A minor amount of magnesium stearate is added as a lubricant. The mixture is formed into 240-270 mg tablets (80-90 mg of active azolidinone compound per tablet) in a tablet press.

### Formulation 2 – Capsules

A compound of formula (I) is admixed as a dry powder with a starch diluent in an approximate 1:1 weight ratio. The mixture is filled into 250 mg capsules (125 mg of active azolidinone compound per capsule).

### Formulation 3 – Liquid

A compound of formula (I) (1250 mg), sucrose (1.75 g) and xanthan gum (4 mg) are blended, passed through a No. 10 mesh U.S. sieve, and then mixed with a previously prepared solution of microcrystalline cellulose and sodium carboxymethyl cellulose (11:89, 50 mg) in water. Sodium benzoate (10 mg), flavor, and color are diluted with water and added with stirring. Sufficient water is then added to produce a total volume of 5 mL.

### Formulation 4 – Tablets

A compound of formula (I) is admixed as a dry powder with a dry gelatin binder in an approximate 1:2 weight ratio. A minor amount of magnesium stearate is added as a lubricant. The mixture is formed into 450-900 mg tablets (150-300 mg of active azolidinone compound) in a tablet press.

### Formulation 5 – Injection

A compound of formula (I) is dissolved in a buffered sterile saline injectable aqueous medium to a concentration of approximately 5 mg/ml.

### Example 14 : Biological assays

A. a) High Throughput PI3K lipid kinase assay (binding assay):

The assay combines the scintillation proximity assay technology (SPA, Amersham) with the capacity of neomycin (a polycationic antibiotic) to bind phospholipids with high affinity and specificity. The Scintillation Proximity Assay is based on the properties of weakly emitting isotopes (such as  $^3\text{H}$ ,  $^{125}\text{I}$ ,  $^{33}\text{P}$ ). Coating SPA beads with neomycin allows the detection of phosphorylated lipid substrates after incubation with recombinant PI3K

and radioactive ATP in the same well, by capturing the radioactive phospholipids to the SPA beads through their specific binding to neomycin.

To a 384 wells MTP containing 5  $\mu$ l of the test compound of formula (I) (solubilized in 6% DMSO; to yield a concentration of 100, 30, 10, 3, 1, 0.3, 0.1, 0.03, 0.01, 0.001  $\mu$ M of the test compound), the following assay components are added. 1) 5  $\mu$ l (58 ng) of Human recombinant GST-PI3K $\gamma$  (in Hepes 40 mM, pH 7.4, DTT 1 mM and ethylenglycol 5%) 2) 10  $\mu$ l of lipid micelles and 3) 10  $\mu$ l of Kinase buffer ([ $^{33}$ P] $\gamma$ -ATP 45 $\mu$ M/60nCi, MgCl<sub>2</sub> 30mM, DTT 1mM,  $\beta$ -Glycerophosphate 1mM, Na<sub>3</sub>VO<sub>4</sub> 100  $\mu$ M, Na Cholate 0.3 %, in Hepes 40 mM, pH 7.4). After incubation at room temperature for 180 minutes, with gentle agitation, the reaction is stopped by addition of 60  $\mu$ l of a solution containing 100  $\mu$ g of neomycin-coated PVT SPA beads in PBS containing ATP 10mM and EDTA 5mM. The assay is further incubated at room temperature for 60 minutes with gentle agitation to allow binding of phospholipids to neomycin-SPA beads. After precipitation of the neomycin-coated PVT SPA beads for 5 minutes at 1500 x g, radioactive *PtdIns(3)P* is quantified by scintillation counting in a Wallac MicroBeta <sup>TM</sup> plate counter.

The values indicated in respect of PI3K  $\gamma$  refer to the IC<sub>50</sub> ( $\mu$ M), i.e. the amount necessary to achieve 50% inhibition of said target. Said values show a considerable potency of the azolidinone-vinyl fused-benzene compounds with regard to PI3K $\gamma$ .

The tested compounds according to formula (I) display an inhibition (IC<sub>50</sub>) with regard to PI3K $\gamma$  of less than 2  $\mu$ M, more preferred equal or less than 1  $\mu$ M.

Examples of inhibitory activities for test compounds 41, 61, 66, 73, 103, 107, and 110 as set out in Table 1.

<i>Example No</i>	<i>PI3K<math>\gamma</math>, IC<sub>50</sub> (<math>\mu</math> M)</i>
<b>41</b>	< 1
<b>61</b>	< 1
<b>66</b>	< 1
<b>73</b>	< 1
<b>103</b>	< 1
<b>107</b>	< 1
<b>110</b>	< 1

Table 1: IC<sub>50</sub> values of azolidinone-vinyl fused-benzene derivatives against PI3K $\gamma$ .

b) Cell based ELISA to monitor PI3K inhibition:

- 5 Measurement of Akt/PKB phosphorylation in macrophages after stimulation with C5a:  
Raw 264: Raw 264-7 macrophages (cultured in DMEM-F12 medium containing 10% Fetal Calf serum and antibiotics) are plated at 20'000 cells/well in a 96 MTP 24 h before cell stimulation. Previous to the stimulation with 50 nM of Complement 5a (C5a; which is a well known chemokine which stimulates the used cells) during 5 minutes, Cells are
10 serum starved for 2h, and pretreated with inhibitors for 20 minutes. After stimulation cells are fixed in 4% formaldehyde for 20 minutes and washed 3 times in PBS containing 1% Triton X-100 (PBS/Triton). Endogenous peroxidase is blocked by a 20 minutes incubation in 0.6% H<sub>2</sub>O<sub>2</sub> and 0.1% Sodium Azide in PBS/Triton and washed 3 times in PBS/Triton. Cells are then blocked by 60 minutes incubation with 10% fetal calf serum in PBS/Triton.
15 Next, phosphorylated Akt/PKB is detected by an overnight incubation at 4°C with first antibody (anti phospho Serine 473 Akt IHC, Cell Signaling) diluted 800-fold in PBS/Triton, containing 5% bovine serum albumin (BSA). After 3 washes in PBS/Triton, cells are incubated for 60 minutes with a peroxidase conjugated goat-anti-rabbit antibody (1/400 dilution in PBS/Triton, containing 5% BSA), washed 3 times in PBS/Triton, and 2
20 times in PBS and further incubated in 100  $\mu$ l of substrate reagent solution (R&D) for 20

minutes. The reaction is stopped by addition of 50  $\mu$ l of 1 M  $H_2SO_4$  and absorbance is read at 450 nm.

The values indicated reflect the percentage of inhibition of AKT phosphorylation as compared to basal level. Said values show a clear effect of the azolidinone-vinyl fused-benzene compounds on the activation of AKT phosphorylation in macrophages.

Compounds of examples 1, 19, 66 and 107, when used at 10  $\mu$ M completely (about 100%) inhibit C5a-mediated AKT phosphorylation. Examples 17, 19 or 73, when used at 1  $\mu$ M, inhibit 95% of the C5a-mediated AKT-phosphorylation.

B. *In vitro* experiments:

In the experiments the following examples are based on, standard methods of *in vitro* fertilization have been used. With regard to the details of these methods, reference is made to the "WHO manual" (WHO laboratory manual for the examination of human semen and sperm-cervical mucus interactions, 4<sup>th</sup> edition, Cambridge University Press 1999). In particular, the direct swim-up method can be taken from pp. 104 to 106 of this manual.

a) Effect of the PI3K inhibitor on the rapid motility of spermatozoa:

Spermatozoa are prepared according to the standard procedures of IVF. Briefly, spermatozoa are prepared from 3 oligoasthenospermic subjects undergoing semen analysis for couple infertility after informed consent. 10  $\mu$ M of the tested compound of formula (I) are added directly to the seminal liquid and incubated for 2 hours for two hours at 37°C and 5%  $CO_2$ . The motility of the spermatozoa is then blindly evaluated under the microscope according to WHO manual procedures.

In a group of 7 samples taken from seven individuals, the tested phosphatidylinositol-3-kinase inhibitor is added in a higher concentration (100  $\mu$ M). After the incubation with the compound for two hours, swim-up selection of the spermatozoa is performed according to procedures described in the WHO-manual. The incubation of the sperm cells with a ten

times higher concentration of the compound of formula (I) (100  $\mu$ M) in combination with the swim-up selection results in a significant increase of progressive motility in all of the seven samples.

Results may be obtained in a similar experiment on samples from higher numbers of patients. The sperm cells are submitted to the swim-up selection method. Treatment with 10 $\mu$ M of the tested phosphatidylinositol-3-kinase inhibitor results in an increase in the progressive motility as compared to the control (patients without LY294002). Treatment of samples from patients with 100 $\mu$ M of the inhibitor results in an increase of the motility as compared to the control.

The effect of 100 $\mu$ M of the compound of formula (I) on the viability of the spermatozoa is also assessed. The incubation with the tested PI3K inhibitor is carried out to observe the alteration of the vitality of the cells for two hours and after 48 hours.

Further experiment may be carried out in the same manner as outlined above on samples from 12 individual patients.

b) Effect of example 1 compound on further sperm cell parameters:

The increase in forward motility, demonstrated in the above mentioned part A, is associated with an increase in sperm parameters related to fertilization activity of the spermatozoa *in vitro*, such as percentage curvilinear velocity (VCL), average path velocity (VAP), straight-line velocity (VSL) and hyper-activated sperm fraction (HA). These parameters are determined by computer aided sperm analysis (CASA) in sperm samples from different oligo-asthenospermic subjects. Each of these parameters are increased in a statistically significant manner by incubation with 10  $\mu$ M of compound of example 1 as compared to the control sample, indicating a significant overall improvement of sperm cell fertilization activity.

c) Effect of the tested compound of formula (I) on forward motility of H<sub>2</sub>O<sub>2</sub> or LiCl treated spermatozoa:



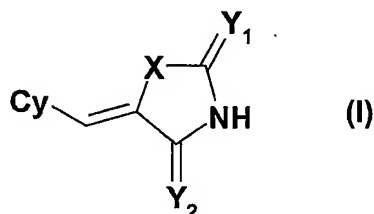
It is well known that reactive oxygen species (ROS), which may be generated during sperm preparation for IVF, exert detrimental effects on sperm fertilization potential. In particular, among ROS,  $H_2O_2$  strongly reduces motility when added to sperm samples at micromolar concentrations. Therefore, the effect of the tested compound of formula (I) on  $H_2O_2$  treated sperm cells is evaluated. The compound is added to swim-up selected spermatozoa samples from oligo-asthenospermic patients in amounts of 10  $\mu M$  either alone or in combination with 200  $\mu M$  of  $H_2O_2$ .

LiCl is known as having inhibition properties on sperm cell motility. An incubation of swim-up selected spermatozoa with 10  $\mu M$  of tested compound of formula (I) for two hours either with or without different concentrations of LiCl results in reversing the effect of LiCl induced inhibition of sperm motility.

In this example, the activity of compounds of formula (I) to rescue spermatozoa from deleterious agents, which may be generated in assisted fertilization techniques has been demonstrated. Therefore, the invention provides for a major improvement of ART, leading to a higher fertilization rate and eliminating some of the most serious drawbacks of these techniques.

# Claims

1. Process for improving the fertilization activity of spermatozoa, in particular for increasing spermatozoa motility, comprising the step of treating spermatozoa with a compound of formula (I)



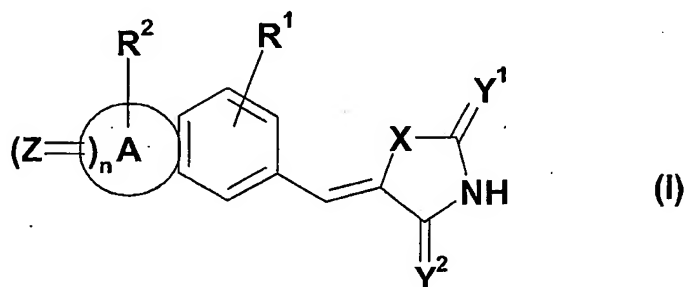
as well as its geometrical isomers, its optically active forms as enantiomers, diastereomers and its racemate forms, as well as pharmaceutically acceptable salts and pharmaceutically active derivatives thereof, wherein

X is S, O or NH;

Y<sup>1</sup> and Y<sup>2</sup> are independently S, O or -NH;

Cy is a 5 to 8 membered carbocyclic or heterocyclic group may be fused with an aryl, heteroaryl, cycloalkyl or heterocycloalkyl group.

2. Process according to claim 1, whereby the compound has formula (I')



A is a 5-8 membered heterocyclic or carbocyclic group, wherein said carbocyclic group may be fused with aryl, heteroaryl, cycloalkyl or heterocycloalkyl;

X is S, O or NH;

$Y^1$  and  $Y^2$  are independently S, O or -NH;

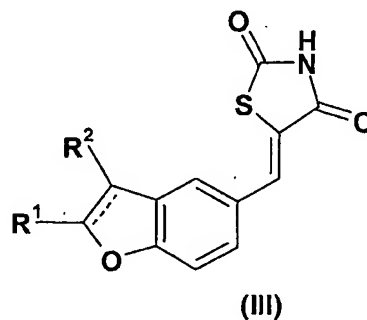
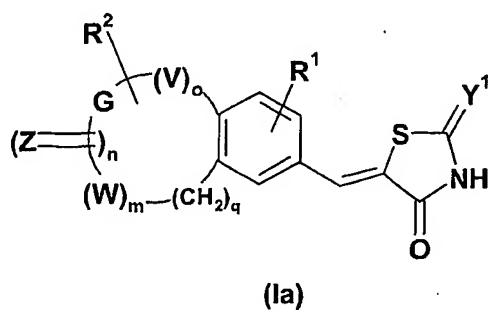
5 Z is S or O;

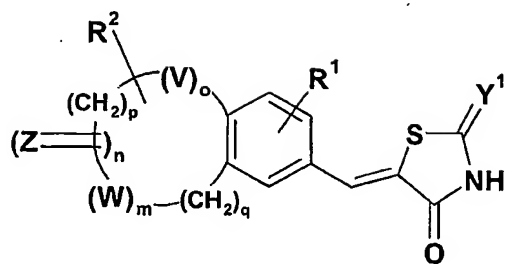
$R^1$  is H, CN, carboxy, acyl,  $C_1$ - $C_6$ -alkoxy, halogen, hydroxy, acyloxy,  $C_1$ - $C_6$ -alkyl carboxy,  $C_1$ - $C_6$ -alkyl acyloxy,  $C_1$ - $C_6$ -alkyl alkoxy, alkoxycarbonyl,  $C_1$ - $C_6$ -alkyl alkoxycarbonyl, aminocarbonyl,  $C_1$ - $C_6$ -alkyl aminocarbonyl, acylamino,  $C_1$ - $C_6$ -alkyl acylamino, ureido,  $C_1$ - $C_6$ -alkyl ureido, amino,  $C_1$ - $C_6$ -alkyl amino, ammonium, sulfonyloxy,  $C_1$ - $C_6$ -alkyl sulfonyloxy, sulfonyl,  $C_1$ - $C_6$ -alkyl sulfonyl, sulfinyl,  $C_1$ - $C_6$ -alkyl sulfinyl, sulfanyl,  $C_1$ - $C_6$ -alkyl sulfanyl, sulfonylamino,  $C_1$ - $C_6$ -alkyl sulfonylamino or carbamate;

$R^2$  is selected from the group comprising or consisting of H, halogen, acyl, amino,  $C_1$ - $C_6$ -alkyl,  $C_2$ - $C_6$ -alkenyl,  $C_2$ - $C_6$ -alkynyl,  $C_1$ - $C_6$ -alkyl carboxy,  $C_1$ - $C_6$ -alkyl acyl,  $C_1$ - $C_6$ -alkyl alkoxycarbonyl,  $C_1$ - $C_6$ -alkyl aminocarbonyl,  $C_1$ - $C_6$ -alkyl acyloxy,  $C_1$ - $C_6$ -alkyl acylamino,  $C_1$ - $C_6$ -alkyl ureido,  $C_1$ - $C_6$ -alkyl amino,  $C_1$ - $C_6$ -alkyl alkoxy,  $C_1$ - $C_6$ -alkyl sulfanyl,  $C_1$ - $C_6$ -alkyl sulfinyl,  $C_1$ - $C_6$ -alkyl sulfonyl,  $C_1$ - $C_6$ -alkyl sulfonylaminoaryl, aryl,  $C_3$ - $C_8$ -cycloalkyl or heterocycloalkyl,  $C_1$ - $C_6$ -alkyl aryl,  $C_2$ - $C_6$ -alkenyl-aryl,  $C_2$ - $C_6$ -alkynyl aryl, carboxy, cyano, hydroxy,  $C_1$ - $C_6$ -alkoxy, nitro, acylamino, ureido,  $C_1$ - $C_6$ -alkyl carbamate, sulfonylamino, sulfanyl, or sulfonyl;

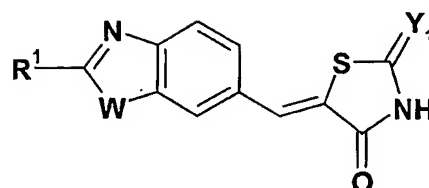
n is 0, 1 or 2.

3. Process according to claim 1 or 2, wherein the compound is selected from any of formulae (Ia), (Ib), (Ic) or (Id)

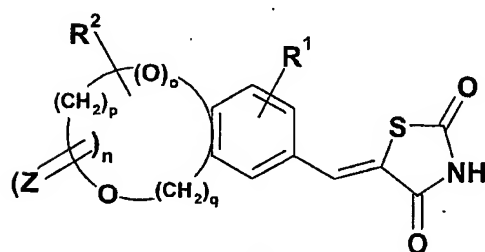




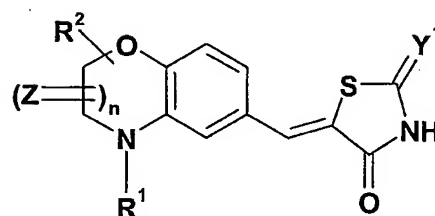
(Ib)



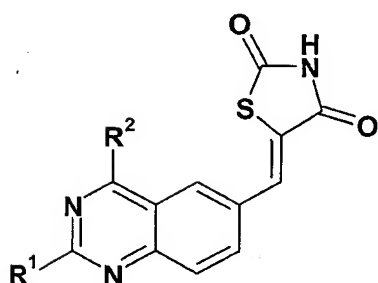
(Ic)



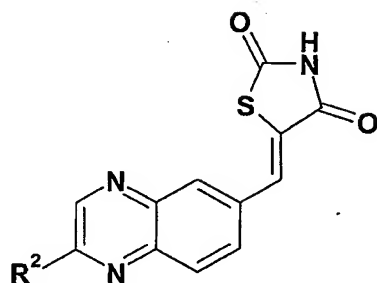
(Id)



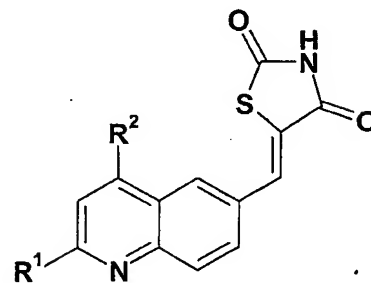
(II)



(IV)



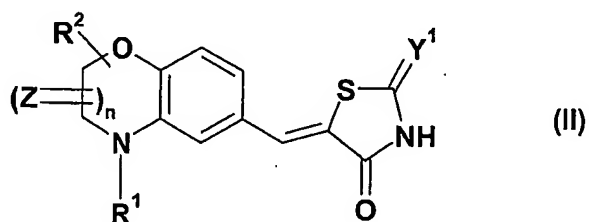
(V)



(VI)

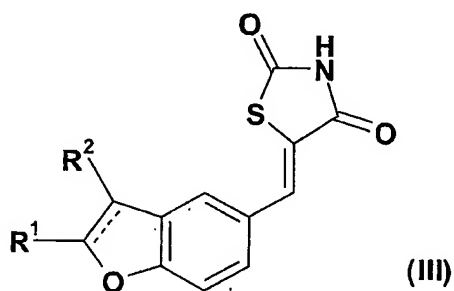
wherein  $R^1$ ,  $R^2$ ,  $Y^1$ ,  $Z$  and  $n$  are as above-defined,  $G$  is a  $C_1$ - $C_5$  alkylene or a  $C_1$ - $C_5$  alkenylene group,  $W$  and  $V$  are each independently from each other selected from  $O$ ,  $S$ ,  $-NR^3$  wherein  $R^3$  is  $H$  or a  $C_1$ - $C_6$  alkyl group,  $m$ ,  $n$  and  $o$  are each independently from each other 0 or 1,  $p$  and  $q$  are independently from each other an integer from 1 to 4.

4. Process according to any of the preceding claims, wherein the compound has formula (II)



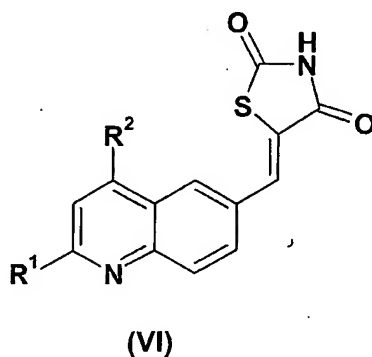
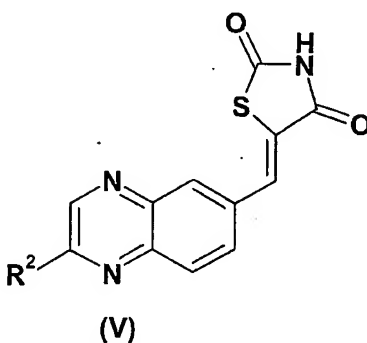
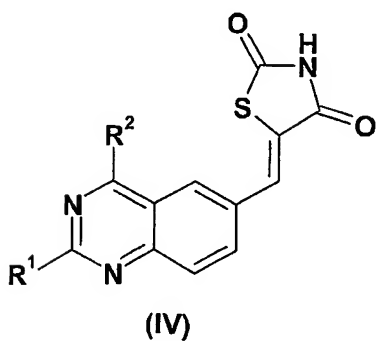
wherein Z, Y<sup>1</sup>, R<sup>1</sup>, R<sup>2</sup> are as above defined; n is 0 or 1.

5. Process according to any of claims 1 to 3, wherein the compound has formula (III)



wherein R<sup>1</sup> and R<sup>2</sup> are as above defined.

6. Process according to any of claims 1 to 3, wherein the compound has any of formulae (IV), (V) or (VI);



wherein R<sup>1</sup> and R<sup>2</sup> are as above defined.

7. Process according to any of claims 1 to 6, wherein treating the spermatozoa with the compound of formula (I) is performed on seminal liquid comprising the spermatozoa.

8. Process according to any of claims 1 to 7, further comprising separating the spermatozoa by spermatozoa separation methods used in assisted reproduction techniques.
9. Process according to claim 8, wherein separating the spermatozoa is performed by a method selected from the wash and spin method, the sedimentation method, the direct swim-up method, the pellet and swim-up method, the buoyant density gradient method.
10. Process according to claim 9, wherein separating the spermatozoa is performed by the direct swim-up method.
11. Process according to any of the preceding claims, wherein the process is performed on mammal spermatozoa, in particular on human spermatozoa.
12. Process according to any of the preceding claims, wherein the compound of formula (I) is selected from the group consisting of :
  - 5-(1,3-benzodioxol-5-ylmethylene)-1,3-thiazolidine-2,4-dione
  - 5-(1,3-benzodioxol-5-ylmethylene)-2-thioxo-1,3-thiazolidin-4-one
  - 5-(2,3-dihydro-1,4-benzodioxin-6-ylmethylene)-1,3-thiazolidine-2,4-dione
  - 5-(2,3-dihydro-1-benzofuran-5-ylmethylene)-1,3-thiazolidine-2,4-dione
  - 5-[(7-methoxy-1,3-benzodioxol-5-yl)methylene]-1,3-thiazolidine-2,4-dione
  - 5-[(9,10-dioxo-9,10-dihydroanthracen-2-yl)methylene]-1,3-thiazolidine-2,4-dione
  - 5-[(2,2-difluoro-1,3-benzodioxol-5-yl)methylene]-1,3-thiazolidine-2,4-dione
  - (5Z)-5-(1,3-dihydro-2-benzofuran-5-ylmethylene)-1,3-thiazolidine-2,4-dione
  - 5-(1-benzofuran-5-ylmethylene)-1,3-thiazolidine-2,4-dione
  - 5-[(4-methyl-3-oxo-3,4-dihydro-2H-1,4-benzoxazin-6-yl)methylene]-1,3-thiazolidine-2,4-dione
  - 5-(1,3-benzodioxol-5-ylmethylene)-2-imino-1,3-thiazolidin-4-one
  - 5-Quinolin-6-ylmethylene-thiazolidine-2,4-dione
  - 5-Quinolin-6-ylmethylene-2-thioxo-thiazolidin-4-one

2-Imino-5-quinolin-6-ylmethylene-thiazolidin-4-one

5-(3-Methyl-benzo[d]isoxazol-5-ylmethylene)-thiazolidine-2,4-dione

5-(4-Phenyl-quinazolin-6-ylmethylene)-thiazolidine-2,4-dione

5-(4-Dimethylamino-quinazolin-6-ylmethylene)-thiazolidine-2,4-dione

5-[(4-aminoquinazolin-6-yl)methylene]-1,3-thiazolidine-2,4-dione

5-[(4-piperidin-1-ylquinazolin-6-yl)methylene]-1,3-thiazolidine-2,4-dione

5-[(4-morpholin-4-ylquinazolin-6-yl)methylene]-1,3-thiazolidine-2,4-dione

5-{[4-(benzylamino)quinazolin-6-yl]methylene}-1,3-thiazolidine-2,4-dione

5-{[4-(diethylamino)quinazolin-6-yl]methylene}-1,3-thiazolidine-2,4-dione

5-({4-[(pyridin-2-ylmethyl)amino]quinazolin-6-yl}methylene)-1,3-thiazolidine-2,4-dione

5-({4-[(pyridin-3-ylmethyl)amino]quinazolin-6-yl}methylene)-1,3-thiazolidine-2,4-dione

ethyl 1-{6-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]quinazolin-4-yl}piperidine-3-carboxylate

ethyl 1-{6-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]quinazolin-4-yl}piperidine-4-carboxylate

tert-butyl 1-{6-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]quinazolin-4-yl}-L-prolinate

5-{[4-(4-methylpiperazin-1-yl)quinazolin-6-yl]methylene}-1,3-thiazolidine-2,4-dione

5-{[4-(4-pyrimidin-2-ylpiperazin-1-yl)quinazolin-6-yl]methylene}-1,3-thiazolidine-2,4-dione

5-({4-[4-(4-fluorophenyl)piperidin-1-yl]quinazolin-6-yl}methylene)-1,3-thiazolidine-2,4-dione

5-{[4-(4-benzylpiperidin-1-yl)quinazolin-6-yl]methylene}-1,3-thiazolidine-2,4-dione

5-({4-[4-(2-phenylethyl)piperidin-1-yl]quinazolin-6-yl}methylene)-1,3-thiazolidine-2,4-dione

5-{[4-(4-methylpiperidin-1-yl)quinazolin-6-yl]methylene}-1,3-thiazolidine-2,4-dione

5-{[4-(4-hydroxypiperidin-1-yl)quinazolin-6-yl]methylene}-1,3-thiazolidine-2,4-dione

1-[6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-quinazolin-4-yl]-piperidine-4-carboxylic acid

1-[6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-quinazolin-4-yl]-piperidine-3-carboxylic acid

1-[6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-quinazolin-4-yl]-pyrrolidine-2-carboxylic acid

5-(4-Methylamino-quinazolin-6-ylmethylene)-thiazolidine-2,4-dione

5-(4-Methoxy-quinazolin-6-ylmethylene)-thiazolidine-2,4-dione

2-Imino-5-(4-methylamino-quinazolin-6-ylmethylene)-thiazolidin-4-one

2-Imino-5-(4-piperidine-quinazolin-6-ylmethylene)-thiazolidin-4-one

2-Imino-5-(4-dimethylamino-quinazolin-6-ylmethylene)-thiazolidin-4-one

5-(2-Methyl-2H-benzotriazol-5-ylmethylene)-thiazolidine-2,4-dione

5-(3-Methyl-3H-benzotriazol-5-ylmethylene)-thiazolidine-2,4-dione

5-(3-Ethyl-3H-benzoimidazol-5-ylmethylene)-thiazolidine-2,4-dione

5-{{1-(4-phenylbutyl)-1H-benzimidazol-6-yl}methylene}-1,3-thiazolidine-2,4-dione

5-[(1-prop-2-yn-1-yl-1H-benzimidazol-6-yl)methylene]-1,3-thiazolidine-2,4-dione

5-[(1-{2-[4-(trifluoromethyl)phenyl]ethyl}-1H-benzimidazol-6-yl)methylene]-1,3-thiazolidine-2,4-dione

5-({1-[2-(4-hydroxyphenyl)ethyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione

methyl 4-{6-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1H-benzimidazol-1-yl}cyclohexanecarboxylate

5-({1-[2-(5-methoxy-1H-indol-3-yl)ethyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione

5-({1-[(1-methyl-1H-pyrazol-4-yl)methyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione

5-({1-[2-(3,4-dimethoxyphenyl)ethyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione

5-({1-[2-(4-phenoxyphenyl)ethyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione

5-({1-[4-(trifluoromethyl)benzyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione

4-{6-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1H-benzimidazol-1-yl}cyclohexanecarboxylic acid



- 5-[(1-isobutyl-1H-benzimidazol-6-yl)methylene]-1,3-thiazolidine-2,4-dione
- 5-({1-[2-(1,3-benzodioxol-4-yl)ethyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione
- 5-({1-[2-(2-phenoxyphenyl)ethyl]-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione
- 5-({1-(3,3-diphenylpropyl)-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione
- 5-({1-(2-methoxybenzyl)-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione
- 5-({1-(3-furylmethyl)-1H-benzimidazol-6-yl}methylene)-1,3-thiazolidine-2,4-dione
- 5-[(1-propyl-1H-benzimidazol-6-yl)methylene]-1,3-thiazolidine-2,4-dione
- 5-Quinoxalin-6-ylmethylene-thiazolidine-2,4-dione
- 5-Quinoxalin-6-ylmethylene-2-thioxo-thiazolidin-4-one
- 2-Imino-5-quinoxalin-6-ylmethylene-thiazolidin-4-one
- 5-Benzothiazol-6-ylmethylene-thiazolidine-2,4-dione
- 5-(3-Methyl-benzofuran-5-ylmethylene)-thiazolidine-2,4-dione
- 5-(2-Bromo-3-methyl-benzofuran-5-ylmethylene)-thiazolidine-2,4-dione
- 5-(3-bromo-benzofuran-5-ylmethylene)-thiazolidine-2,4-dione
- 3-[5-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-benzofuran-3-yl]-acrylic acid ethyl ester
- 3-[5-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-benzofuran-3-yl]-acrylic acid
- 5-[3-(3-Oxo-3-piperidin-1-yl-propenyl)-benzofuran-5-ylmethylene]-thiazolidine-2,4-dione
- Methyl 1-((3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}prop-2-enoyl)prolinate
- Methyl 1-((3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}prop-2-enoyl)-D-prolinate
- 5-({3-[(3-oxo-3-pyrrolidin-1-ylprop-1-en-1-yl)-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione
- 5-({3-[3-morpholin-4-yl-3-oxoprop-1-en-1-yl]-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione
- Methyl 1-(3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}prop-2-enoyl)-L-prolinate

- N-cyclohexyl-3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}-N-methylacrylamide
- 3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}-N-ethyl-N-(2-hydroxyethyl)acrylamide
- N-cyclobutyl-3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}acrylamide
- 5-({3-[3-azetidin-1-yl-3-oxoprop-1-en-1-yl]-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione
- 5-({3-[3-(1,3-dihydro-2H-isoindol-2-yl)-3-oxoprop-1-en-1-yl]-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione
- 5-({3-[3-azepan-1-yl-3-oxoprop-1-en-1-yl]-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione
- 3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}-N-piperidin-1-ylacrylamide
- 3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}-N-(pyridin-3-ylmethyl)acrylamide
- N-cyclohexyl-3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}acrylamide
- 5-({3-[3-(4-methylpiperazin-1-yl)-3-oxoprop-1-en-1-yl]-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione
- N-cycloheptyl-3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}acrylamide
- 5-({3-[3-(2,5-dihydro-1H-pyrrol-1-yl)-3-oxoprop-1-en-1-yl]-1-benzofuran-5-yl}methylene)-1,3-thiazolidine-2,4-dione
- N-cyclopentyl-3-{5-[(2,4-dioxo-1,3-thiazolidin-5-ylidene)methyl]-1-benzofuran-3-yl}acrylamide
- 3-[5-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-benzofuran-3-yl]-propionic acid ethyl ester
- 3-[5-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-benzofuran-3-yl]-propionic acid
- 5-[3-(3-Oxo-3-piperidin-1-yl-propyl)-benzofuran-5-ylmethylene]-thiazolidine-2,4-dione
- 6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-2,3-dihydro-benzo[1,4]oxazine-4-carboxylic acid tert-butyl ester
- 5-(3,4-Dihydro-2H-benzo[1,4]oxazin-6-ylmethylene)-thiazolidine-2,4-dione
- 5-(4-Benzoyl-3,4-dihydro-2H-benzo[1,4]oxazin-6-ylmethylene)-thiazolidine-2,4-dione

5-(4-Acetyl-3,4-dihydro-2H-benzo[1,4]oxazin-6-ylmethylene)-thiazolidine-2,4-dione  
6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-benzo[1,4]oxazine-4-carboxylic acid tert-butyl ester

[6-(2,4-Dioxo-thiazolidin-5-ylidenemethyl)-3-oxo-2,3-dihydro-benzo[1,4]-oxazin-4-yl]-acetic acid methyl ester

N-Benzyl-2-[6-(2,4-dioxo-thiazolidin-5-ylidenemethyl)-3-oxo-2,3-dihydro-benzo[1,4]oxazin-4-yl]-acetamide

5-(4-Butyl-3-oxo-3,4-dihydro-2H-benzo[1,4]oxazin-6-ylmethylene)-thiazolidine-2,4-dione

5-(4-Benzyl-3-oxo-3,4-dihydro-2H-benzo[1,4]oxazin-6-ylmethylene)-thiazolidine-2,4-dione

5-(2-Chloro-benzofuran-5-ylmethylene)-thiazolidine-2,4-dione

5-(3-Amino-benzo[d]isoxazol-5-ylmethylene)-thiazolidine-2,4-dione

5-(3-Phenylethynyl-benzofuran-5-ylmethylene)-thiazolidine-2,4-dione

5-Benzo[1,2,5]thiadiazol-5-ylmethylene-thiazolidine-2,4-dione

5-Benzo[1,2,5]oxadiazol-5-ylmethylene-thiazolidine-2,4-dione

5-(2-Methyl-benzofuran-6-ylmethylene)-thiazolidine-2,4-dione

5-(2-Carboxymethyl-benzofuran-6-ylmethylene)-thiazolidine-2,4-dione

5-(3-Bromo-2-fluoro-2,3-dihydro-benzofuran-6-ylmethylene)-thiazolidine-2,4-dione

5-(2-Fluoro-benzofuran-6-ylmethylene)-thiazolidine-2,4-dione

13. Process according to any of the preceding claims, wherein said spermatozoa are treated with an amount of a compound of formula (I) in the range of about 0.01 to 1000  $\mu\text{M}$ , about 5 to 500  $\mu\text{M}$ , or about 10 to 100  $\mu\text{M}$ .

14. Process according to any of the preceding claims, wherein treating the spermatozoa with a compound of formula (I) comprises incubating the spermatozoa for a period of

time in the range of about 30 minutes to 10 hours or about 1 to 8 hours or about 2 to 6 hours at a temperature of around 37°C.

15. Spermatozoa obtainable by the process according to any of claims 1 to 14.
16. Use of a compound according to formula (I) for improving the fertilization rate in  
5 assisted reproduction techniques.
17. Use according to claim 14, wherein the assisted reproduction techniques are selected from in vitro fertilization (IVF), gamete intrafallopian transfer (GIFT), or intra-uterine insemination (IUI).
18. Use of a compound according to formula (I) for the preparation of a pharmaceutical  
10 composition for the treatment of infertility, in particular male infertility.
19. Use of a compound according to any of formula (I) for the preparation of a pharmaceutical composition for improving spermatozoa fertilization activity, in particular for increasing spermatozoa motility.
20. Method of ART therapy, comprising treating spermatozoa with a compound of any of  
15 formulae (I) as above-defined.
21. Method according to claim 20, wherein said ART are selected from in vitro fertilization (IVF), gamete intrafallopian transfer (GIFT), or intra-uterine insemination (IUI).
22. A medium for storage and/or transportation of spermatozoa comprising a compound of any of formula (I).
- 20 23. Medium according to claim 22 for the storage and/or transportation of mammal spermatozoa, in particular human spermatozoa.
24. Medium according to any of claims 22 or 23, comprising an amount of a compound of formula (I) in the range of about 0.01 to 1000  $\mu\text{M}$ , about 5 to 500  $\mu\text{M}$ , or about 10 to 100  $\mu\text{M}$ .

## INTERNATIONAL SEARCH REPORT

International Application No.

PCT/EP 03/50303

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 A61K31/426 A61K31/423 A61K31/428 A61K31/538 A61K31/4166  
 A61K31/4168 A61K31/422 A01N1/02

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 A61K A01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, CHEM ABS Data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 01 07021 A (FORTI GIANNI; LUCONI MICHAELA (IT); BALDI ELISABETTA (IT); APPLIED) 1 February 2001 (2001-02-01) cited in the application	1-14, 16-24
X	page 2, paragraph 5 -page 4, paragraph 2; claims 1-25	15
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☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

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## INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 03/50303

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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A	& RO 64 820 A (ROM.) 15 November 1978 (1978-11-15) -----	1-24

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